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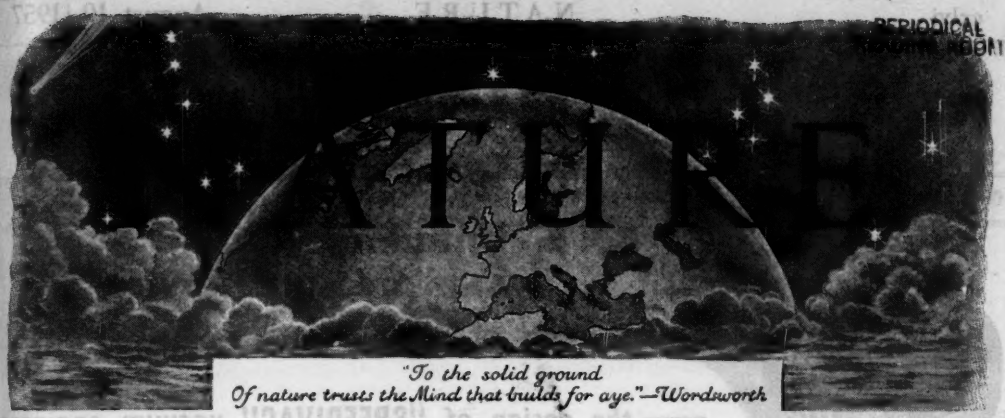

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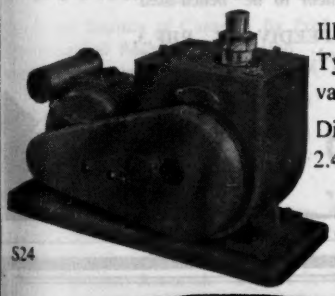

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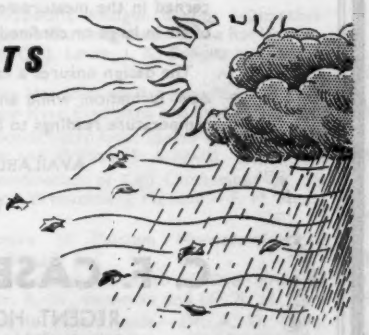

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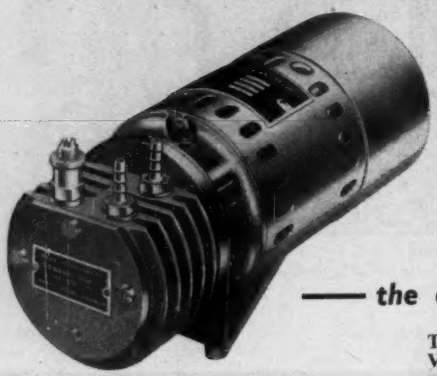

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NATURE

No. 4580 SATURDAY, AUGUST 10, 1957 Vol. 180

CONTENTS

	Page
Treatment of the Mentally Ill	253
Peaceful Uses of Atomic Energy. By Dr. T. E. Allibone, F.R.S.	254
Communication Theory. By J. T. Allanson and Prof. Alan S. C. Ross	255
Hormones in Gestation. By Prof. R. A. McCance, C.B.E., F.R.S.	256
Immunology : Research and Teaching. By Prof. J. R. Marrack	257
The Royal Society of Canada. By Prof. W. H. Watson	259
The Electrical Research Association	260
How Glue Sticks. By Dr. Norman A. de Bruyne	262
Obituary :	
Dr. L. H. Lampitt. By Dr. E. B. Hughes	266
News and Views	267
British Electrical and Allied Industries Research Association. By Prof. J. Greig	271
Forestry in the Commonwealth	272
The Physical Society	272
Water Pollution Research. By Dr. T. T. Macan	273
Taste and Smell. By D. Neville-Jones	274
Use of Isotopes in Agriculture. By Dr. E. C. Humphries	275
School Natural History Societies	276
Oxford Botanic Garden. By T. H. Hawkins	276
Adaptive Radiation of Trapdoor Spiders	277
Visual Pigment of a Decapod Crustacean : the Lobster. By Prof. George Wald and Dr. Ruth Hubbard	278
Directions of Magnetization in the Carboniferous Glacial Varves of Australia. By E. Irving	280

Letters to the Editors :

Nitrogen Fixation by a Species of *Pullularia*.—Dr. Margaret E. Brown and Dr. George Metcalfe	282
Origin of Antibiotic-Resistant Staphylococci.—J. C. Gould	282
Heleococcum aurantiacum : an Uncommon Weed Fungus of Mushroom Compost.—F. C. Wood	283
Relationship between Shoot Apex and Effect of Gibberellic Acid on Elongation of Pea Stems.—A. J. Vlitos and W. Meudt	284
Unisexual Flowers in the Ericales.—E. J. Godley	284
Nature of the Bactericidal Agent in Sea Water.—J. K. Johannesson	285
Separation and Identification of Aromatic Acids in Plant Tissues by Paper Chromatography.—Dr. L. A. Griffiths	286
Ascorbic Acid Content of Baobab Fruit.—Bruce M. Nicol	287
Nucleic Acid Derivatives in Soils.—G. Anderson	287
Isolation of Uranediol from the Urine of Pregnant Mares.—W. L. Glen, R. Barber and G. A. Grant	288
Production of Rat Serum Proteins in Irradiated Mice.—W. W. H. Weyzen and O. Vos	288
Role of Organ-Specific Antigen during 4-Dimethylaminoazobenzene Carcinogenesis in the Rat Liver.—P. E. Hughes, C. J. Louis, J. K. Dineen and W. G. Spector	289
Effect of Relative Humidity on Rat Breeding and Ringtail.—Leif Rein Njaa, Finn Utne and Olaf R. Brækkan	290
Underwater Sounds heard from Sperm Whales.—L. V. Worthington and William E. Schevill	291
Precision Determination of Cell Dimensions by the Back-Reflexion Weissenberg Method.—F. H. Herbstein	291
Crystal Structure of Calcium Monoaluminate.—Maryon W. Dougill	292
Twinning and the Tabular Growth of Silver Bromide Crystals.—Dr. R. W. Berriman and Dr. R. H. Herz	293
Foreign Cations in Silver Azide.—Dr. A. D. Yoffe, B. L. Evans and S. K. Deb	294
A Hydrogen-Conversion Detector for Gas Chromatography.—G. E. Green	295
Photoperiodicity and Wool Growth in Romney Rams and Wethers.—Dr. A. B. Wildman	296
Anisotropy of Sclerotinites.—D. Chandra	297

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TREATMENT OF THE MENTALLY ILL

MENTAL illness is so disturbing and unexpected that it is inevitable that it should arouse an emotional response. This is particularly evident in primitive and uneducated people. The earliest historical reaction seems to have been the view that insanity was due to possession by devils. Hallucinations, which cause the patient to reply to 'voices', and delusions, particularly of persecution, would seem to confirm such a conclusion. It may be that the trephining operation in which palæolithic man removed, with what pain we cannot conceive, sections of a living man's skull, was designed to let out the devils which had somehow become lodged in the head.

The next stage in such a belief was that the patient had suffered from a divine intervention. He was 'touched' by God, just as the brain of the paralysed had undergone a 'stroke' by the same hand. Possibly the wild prophecies and fantastic delusions of some paraphrenics would support such an idea. In some beliefs, for example, the Moslem, the insane are still regarded as possessing holiness.

However, a certain number of mentally ill patients, in spite of the idea that their illness had a divine origin, are definitely dangerous, and many are a nuisance, interfering with the lives and work of ordinary folk. We can imagine the practical man having his say and insisting that these people be restrained. Indeed, in Biblical times, insane people were sometimes chained in caves and dependent on charity for their food, or died if it were not provided. This may be regarded as the beginning of what has been euphemistically called 'custodial treatment'—but which really means shutting the patient up so that he is no longer a danger or a nuisance. They were confined in cells, loaded with arm and leg irons, bled, purged, flogged, and if females seduced, in appalling conditions.

In 1792 Pinel commenced the modern era by removing the patients' shackles in France, and simultaneously Fricke in Germany and Tuke in England started similar reforms. From this time physicians tried to treat their patients, and not merely confine them to a place of safety. Treatment meant understanding the illness. The time of the great classifiers, such as Kraepelin, arrived, and insanity was differentiated from dementia and mental deficiency. Psychiatrists were then beginning to speak the same language.

Better than this, once one case could be distinguished from another (and not merely labelled 'insane') treatments could be discovered, developed, and generally applied. This has finally given us such therapy as insulin, which doubles the recovery-rate of schizophrenia, electrical convulsive therapy which does the same thing for depressives, and so on. The new chemical tranquillizers offer wonderful hopes of reducing the violent, dangerous patient to a sociable, human being.

To turn from the bright hopes which we entertain for the future of psychiatric medicine to the legal position comes almost as a mental shock. The recent report* of the Royal Commission on the laws relating to mental illness and mental deficiency shows that the legal aspects of these disorders are still of importance to the community. It is impossible here to go minutely into the Commission's conclusions, but broadly they diminish the obsolete custodial treatment and the excessive safeguards against wrong certification (which are now unnecessary), and make it easier for voluntary treatment and discharge of recovered patients. In practice, the average psychiatrist rarely certifies anyone, so many will go willingly for treatment, and the scarcity of beds leads to patients being discharged too early rather than to their being unduly detained.

It will be, however, easier to persuade patients to go for treatment, and the mental hospital will lose the residue of the 'stigma' left from the past. The Commission is, therefore, to be congratulated on its labours, and it is hoped that its conclusions will soon become law.

But the law is static: it is banal to say that one cannot heal people by passing statutes, although one can hinder the physician in his work by them. It is not legislation but research and more research which we need. Schizophrenia, that terrible 'cancer' of the mind, is still a mystery. A large majority of the beds in mental hospitals are occupied by schizophrenics and, in spite of modern treatments, those who have been there for any length of time tend to remain most of their life. Manic-depression is not so crippling as schizophrenia but forms a recurring menace, a suspended sword over the patient's head, since he never knows when he may be ill again. The basic cause of these illnesses is still a mystery and its discovery as important as the cause of cancer.

Many organic mental illnesses can now be treated: the syphilitic diseases of the brain have been conquered by penicillin and medical adjuvants, cerebral tumours now yield more to operation, trauma such as that produced by boxing and motor-car accidents is better understood and sometimes preventable; but the functional mental illnesses (without obvious organic basis) still need elucidation.

The Commission rightly directs attention to patients suffering from a psychopathic personality, who so often come into contact with the law, and indeed form a considerable percentage of the prison population. It offers suggestions for disposal and treatment. This is an improvement on the senseless recurrent sentences on men who are not quite sane and not quite insane, the useless judicial admonitions to prisoners who cannot, by their very mental structure, benefit from them, and the eventual

* Report of the Royal Commission on the Law Relating to Mental Illness and Mental Deficiency, 1954–57. Pp. x+306. (Cmnd. 169.) (London: H.M. Stationery Office, 1957.) 10s. 6d. net.

release of sick men who will inevitably receive further sentences without any attempt to understand or treat them.

If it were asked along what lines research should be extended, it might be suggested that the problem is too great for individuals, no matter how devoted or industrious. What is needed is team work: the collection of data from every point of view. Heredity, parental personality, family life, upbringing, development, and complete knowledge of the patient's environment. The individual physique with the physical investigation must form a part, but only a part, of the research. It must never be forgotten that human beings have minds and react mentally as well as physically. Too often in the past has the physical side of mental illnesses been regarded as a respectable area of investigation, whereas the psychological side has been neglected.

The Commission has recommended that the old Board of Control should be abolished as being obsolete. It might well be replaced by a modern Mental Research Council, to suggest, assist financially, and co-ordinate work on this terrible disease.

PEACEFUL USES OF ATOMIC ENERGY

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy

Held in Geneva, 8 August–20 August, 1955. Vol. 1: The World's Requirements for Energy. Pp. xi+479. 8 dollars; 57*s.*; 34 Swiss francs. Vol. 6: Geology of Uranium and Thorium. Pp. x+825. 9 dollars; 63*s.*; 39 Swiss francs.
(New York: United Nations; London: H.M. Stationery Office, 1956.)

THE first volume of the Proceedings of the Geneva Conference is devoted to a very full survey of the world's total energy requirements up to 1975, followed by a further assessment to the year 2000. There are a number of general survey papers, followed by papers from thirty-six countries, setting out their individual needs, so that for many years to come this volume will be consulted by many who want a broad or a detailed picture. Many of the papers trace the rise of industrialization expressed in terms of the harnessing of energy over the past century and try to foresee the future based on the pattern of the past. All scientists are aware of the difficulties they run into in doing this and many of the papers are written with great caution. It will be interesting to consult this volume every few years to see how far the best laid plans have gone astray. Writing two years after the British nuclear energy plans were published, I find our own prophecies are only out by a factor of three in this short time. There may therefore be great surprises in store with regard to the prophecies made even up to 1975, let alone the distant forecasts to A.D. 2000.

The United Nations Department of Economic and Social Affairs has presented here a world review of energy production and requirements. It is rather surprising that the total consumption per capita of energy varies by a factor of only thirty between the under-developed countries, such as India, Pakistan, etc., and the industrialized American giant, but much of this energy is not electrical, and as nuclear energy appears at present to be merely another fuel to be used for the generation of electricity, a more telling ratio is the 5 kWh. of electricity consumed per annum per capita in Pakistan (15 kWh. per capita in India—there are errors of a few 'millions' in Bhabha's paper) and 3,000 kWh. per capita in the United States. Where is the vast increase of electrical energy to come from if the under-developed countries are ever to rise to industrialized nations? The hydro-electric potential of India when fully harnessed can only deliver a total amount of energy about one-seventh of that at present obtained from the burning of cattle dung. If India were to burn coal sufficient to produce the United States per capita consumption of electricity for her population, her coal reserves would disappear in a decade. Neither dung nor coal can help India in the long run, but her uranium and thorium would suffice for more than a century. As Philip Sporn writes: "The very prospect of the achievement is enough to inspire and excite men and nations to efforts at improvement which can have consequences hard to foresee".

The detailed analyses of the many countries present a very diverse picture of the likely use of nuclear energy in the next fifty years. Many countries have fuel reserves adequate for many decades and can see only marginal use of nuclear power unless its cost falls below the cost of generation from coal, oil or hydro-electric plants. Australia, for example, foresees the use of nuclear stations for remote areas to which the cost of bringing coal or high-voltage transmission lines would be high. Canada can foresee the need for a few fairly large stations twenty years hence, and, in the far north, a number of small stations; but the twentieth century is not expected to see extensive generation of electricity in Canada from uranium sources. China, on the other hand, with immense sources of water-power and coal, believes that nuclear stations will supply half her power requirements by the year 2000; the United Kingdom will almost certainly be supplying almost all her needs in like manner by that date. Japan has thin coal seams, difficult to mine, although total reserves are considerable, and in spite of a potential water supply three times the present harnessed figure she fears a serious unbalance between demand and supply before 1975, and, indeed, many other countries can see no solution to their energy requirements by the end of the century other than through nuclear power. The Russian general and detailed plans are conspicuous by their absence from this volume.

The United States are in a very special position. Coal reserves appear to be adequate for a few thousand years, oil and natural gas still supply more than half the total energy expenditure, .98 per cent of houses and farms have electric power, and she leads the world in per capita electric consumption, so the conclusion is justified that for some long time to come the effect of nuclear power on the home and on medium-sized industrial plants is likely to be negligible. Perhaps in the case of very large industrialized consumers with high load factors nuclear power may become important sooner. Her analysis, therefore, of the situation can afford to be more critical and based almost only on competitive costs which differ somewhat with the siting of power stations, although throughout the whole country

generation costs are below 8 mills/kWh. and average half of this. Her experts consider that amortization charges and insurance rates should be assessed higher than for conventional power stations, that life-time load factors of very high value should not be assumed because of the expected rapid improvement in nuclear stations and therefore of obsolescence of the early reactors; but against this the estimated capital cost of large reactors is only 50 per cent higher than the cost of coal-fired stations and is expected to fall appreciably in the second generation of construction. The general result is that her approach is more experimental than in Britain; several large power reactors of different design are being built in parallel to permit study of the technical and engineering problems of each reactor and to assess operating and maintenance costs, but no rapid expansion is foreseen (except in medium-powered naval propulsion reactors, which, unfortunately, are not analysed at all in this volume). After a ten-year period the large-powered nuclear station may be competitive in the eastern half of the United States, and in the last quarter of the century America expects that nuclear power will be assuming a dominant role.

One fault of the Geneva Conference is brought out in this volume: there was no time for the refereeing of papers, with the result that some are far too long and there is much repetition, but the whole account is fascinating in the extreme and will be of historical importance.

How much uranium do we need and how much is there available? What we need depends on the degree to which we can convert uranium-238 to plutonium, and thorium to uranium-233. If we can burn up eventually 33 per cent of naturally occurring uranium, one ton of it is equivalent to a million tons of coal, so a few hundred tons of uranium per annum, a figure which includes an inventory for new stations, will suffice for Great Britain to the end of the century. Volume 6 collects the evidence as to abundance of uranium, and in spite of this element being almost the least common element on the Earth the amount, even in concentrations of 2 lb. to the ton of ore, is enormous. Thorium occurs in concentrations of 10 per cent in the monazite sands of India and Brazil. Commercial uranium ore is largely based on the lower limit that will be purchased in terms of metal content, and in America the present limit is ore containing 0·1 per cent uranium oxide. At lower concentrations there are huge reserves and ultimately astronomical reserves in the ocean, which contains one part in a million of uranium. The uranium-producing nations of the West (and again it should be noted that the U.S.S.R. has made no contribution to this volume of information on the geology of uranium) are estimated to have reserves of more than a million tons, which can be produced at 10 dollars per lb. of oxide, and far more than this in the 30–50 dollars per lb. region. It is stated that although new chemical extraction processes will be developed there is no longer a wide margin between the costs of modern plant and the results which are theoretically possible. This is because of the great technological drive which has been put into the extraction process in a decade.

The main review of the natural occurrence of uranium and thorium is followed by detailed reviews of seventeen countries, and then follow sixty papers from the United States on the geology of different regions. Perhaps this is justified in view of the fact that the expansion has all occurred in such a short time, and maybe this information is not to be found in the specialist journals, but it seems wrong that an International Conference should publish so many contributions from one source, however informative they are in detail.

The papers on prospecting for uranium and thorium are drawn almost entirely from United States and British sources. The intensified prospecting for uranium after the War has been greatly assisted by a wider range of technical methods than ever available in earlier years, but writers emphasize that successful discovery is still generally based on the application of fundamental geological knowledge. The new aids are, of course, primarily based on Geiger and scintillation counters detecting gamma-rays; local surveys are made on foot, regional by car, and thousands of square miles by light aeroplane or helicopters flying at a few hundred feet at most above ground over tracks a quarter of a mile apart. These surveys can detect oxide of general concentration of 0·001 per cent and the regional air surveys have been of particular importance in locating new areas not previously known to contain uranium. These areas are then surveyed in detail from the air and iso-radioactivity contour maps have been compiled for detailed study on foot or by car. Car recording at 30 m.p.h. can detect 0·001 per cent oxide at a distance of 50 ft. Canada reports that there are more persons searching for uranium to-day than for any other metal, and large deposits averaging 0·1 per cent uranium oxide are regarded as worth mining. A base price is about 3 dollars per lb. of oxide.

Some interesting botanical methods of prospecting for uranium are described by the United States Geological Survey. Vanadium, uranium and selenium occur together in certain of the ores of the Colorado Plateau and a correlation was observed between the distribution of selenium-indicator plants and the uranium–vanadium ore carnotite. These plants have tap roots up to ten metres in length and with favourable distribution of ore the plant thrives, so that plant distribution plotted directly on maps or determined from photographs provides a rapid and inexpensive preliminary survey.

T. E. Allibone

COMMUNICATION THEORY

On Human Communication

A Review, a Survey, and a Criticism. By Dr. Colin Cherry. (Studies in Communication.) Pp. xiv+333. (Cambridge, Mass.: Technology Press of Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 54s. net.

IN this book (which is the first of a series entitled "Studies in Communication", edited by W. N. Locke, L. L. Beranek and R. Jakobson), Dr. Cherry treats of the many facets of modern communication theory—among other things, with its impingements upon linguistics, electrical engineering, human physiology and psychology.

It is a little difficult to see to just what audience the book is directed. Dr. Cherry himself states clearly (p. 3) that the book is written for the 'general reader', and its unusually colloquial style would

certainly lend some support to the view that it is. But this reader is assumed to be willing and able to follow the mathematical argument of the chapters on signal analysis and the statistical theory of communication, although unacquainted with the elements of linguistics, logic and psychology. It is indeed clear that the book will be of most value to someone trained in the physical sciences, wishing to be introduced to studies in communication.

The task Dr. Cherry has set himself is probably too great for any single writer and, although he has made a bold attempt to deal with those fields in which he is not himself a specialist, the treatment of problems in applied psychology seems one-sided and there are few—and passing—references to physiological studies. It is, no doubt, understandable that Dr. Cherry, who has made noteworthy contributions to the study of hearing, should concentrate his attention on speech, hearing and language. But to do this is not to give a complete description of the field of human communication, and it is unfortunate that Dr. Cherry has not felt himself able to include, for example, some treatment of neurophysiology and the psychology of vision.

Within his boundaries the author has, however, completed a general survey which is always competent and, in some places, stimulating. All the chapters are well documented—indeed, the book would be worth reading for its references alone. It is well presented, for an American book of 1957 not perhaps too expensive, and there are remarkably few misprints (though several seem to have coincided in "Eugène Oněgin", p. 39, line 6).

There is one thing for which Dr. Cherry deserves great praise: he is almost unique, among the many natural scientists who to-day write about language, in that he really has tried to familiarize himself with the views on language current among specialists in it—that is, among philologists. In this field, Dr. Cherry shows himself a good disciple of that distinguished philologist, Prof. Roman Jakobson.

Some will find cause for regret in the fact that Dr. Cherry has devoted so much space to the discussion of two of the three theories which are fast becoming a plague to the straightforward philologist—those associated with the names of Jakobson, Zipf and Swadesh, respectively. In each of these three cases, what the philologist is worried about to-day is, first, whether the theory is true, and secondly, if it is, whether it is profound or obvious. Those who adhere to the theory of Swadesh will wonder why Dr. Cherry does not mention this, too.

In the book there are, unfortunately, a number of remarks in which lack of clarity or over-generalization gives ground for criticism. We select three linguistic examples: (1) "the establishment of regular syntax [of Ancient Egyptian]" (p. 32)—but presumably the syntax of all languages at all periods is equally 'regular'; (2) "in tone languages, each syllable has either a high or a low tone" (p. 33)—this can clearly only be true of tone languages with two tones (a small minority); (3) "Speech . . . has a most loose grammatical structure" (p. 78)—whatever may this sentence mean?

The glossary of technical terms (pp. 303–7) will be useful, but some of the entries are not helpful; thus, for example, "Descriptive Syntax. The Syntax of historical, ordinary languages"—if any meaning is to be attached to the two defining adjectives, presumably all languages are equally historical and equally ordinary—that Tahitian seems 'extraordinary' to an Englishman is quite irrelevant. And why is there no entry here for the word *prosodic* (p. 94, line 3)? This word, very fashionable in 'London' linguistics, is not intelligible to the 'general reader' (nor, indeed, to the two reviewers).

J. T. Allanson
Alan S. C. Ross

HORMONES IN GESTATION

Gestation

Transactions of the Third Conference, March 6, 7, and 8, 1956, Princeton, N.J. Edited by Prof. Claude A. Villee. Pp. 253. (New York: Josiah Macy, Jr. Foundation, 1957.) 4.75 dollars.

HORMONES are produced during pregnancy by the maternal organism, the fœtus proper and the placenta, but their function is not easy to define, at any rate quantitatively, and their subsequent metabolism and interactions are exceedingly difficult to follow, let alone to interpret.

The members of this conference on gestation began by considering the maternal hormones. Some of these, such as the steroid, progesterone, have been well characterized chemically, and this hormone is one of those which are necessary for the maintenance of pregnancy, although how it does so is still unknown. Others, such as 'relaxin', are of a protein nature; and although some of the effects of this substance were described in 1926 and there is evidence that it is active in human pregnancy, it has been little investigated. Its assay is biological and few improvements have been made in this since it was first described. Remarks such as these might be made about more of the hormones known to be released during a successful gestation, but unfortunately there are other hormones and problems about which we have also got more literature than knowledge. Insulin is a good example. Does it cross the placenta? Does pregnancy mitigate maternal diabetes? Why are the children of diabetic women so large? We just do not know.

The hormones produced by the placenta were next given a good deal of attention. There appear to be a number of these steroids—progesterone among them—and they continue to be liberated by placentæ perfused through the umbilical vessels. This raised the question as to whether the normal destination of these hormones is the mother or the fœtus, but the matter had to be left unsettled.

Improvement in operative technique will no doubt allow the ductless glands of the fœtus to be studied by the classical methods of removal and substitution therapy. The ingenious and cleverly carried out experiments of Wells and Jost have made a start in this direction, but it still seems a little crude to have to tie off the whole head except the lower jaw to exclude the pituitary gland. One wonders whether any of the results obtained are solely due to the lack of a hormone and, if so, of which of the hormones normally secreted by the gland. Nevertheless, the effects described by Jost make very stimulating reading. Dorothy Price opened a discussion on the effect of hormones on sex differentiation in explanted tissues. This technique seems to have an interesting and promising future, but the interpretation of the results will never be easy.

Emphasis has been laid upon the difficulties of this subject, and simplification of the problem cannot be

expected in the account of a Josiah Macy conference, for the proceedings are always reported verbatim. Even the opening speakers are interrupted, and the ensuing arguments and interjections are often somewhat chaotic and may be very irritating to the seeker after knowledge. Nevertheless, there is a great deal of real information in this book in spite of the sense of difficulty and ignorance which pervades the whole issue. Great though the men may be who pioneered so triumphantly the promotion and control of atomic fission, perhaps they had a simpler problem to solve than these biologists. R. A. McCance

IMMUNOLOGY: RESEARCH AND TEACHING

Lectures in Immunochemistry

By Prof. Michael Heidelberger. Pp. x+150. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 4 dollars.

Fundamentals of Immunology

By Prof. William C. Boyd. Third edition, completely revised and rewritten. Pp. xiv+776. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 10 dollars.

Immunology and Serology

By Prof. Philip L. Carpenter. Pp. viii+351. (Philadelphia and London: W. B. Saunders Company, 1956.) 45*s.* 6*d.*

IMMUNOCHEMISTRY, as Kabat and Mayer wrote in 1952, "has of recent years become a discipline in its own right due largely to the development of precise analytical chemical methods for measurement of both antigens and antibodies". No one has done more than Heidelberger in this development of precise methods; the extent of his contribution can be gauged from the number of times that his work is quoted in Boyd's "Fundamentals of Immunology". He has now published six lectures given in Tokyo in 1955, together with three others. On the whole, the book is disappointing, whether as a review of the development of immunochemistry, of Heidelberger's own work or of the present state of immunochemistry. It gives no indication of the extent to which the work on proteins, particularly that of Svedberg, prepared the ground during the 1920's for the view that antibodies are distinct proteins present in antisera in measurable amounts. Although the book includes a chapter on the relations between chemical constitution and immunological specificity, Landsteiner is nowhere mentioned, although his work beginning before 1917 had been the chief influence in dispelling hazy ideas about specificity.

The presentation of the present state of the theory of the formation of precipitates is incomplete. Once it was agreed that antibody molecules have more than one combining site or 'valency', it was obvious that antibody and antigen, if present in suitable ratios, would build up aggregates held together by specific bonds. But that is not the whole story; for this specific aggregation does not account for the formation of precipitates in extreme antibody excess, and it is not altogether certain whether it, alone, accounts for the formation of precipitates at all.

Boyd's book is "an introduction to the science of immunology". The subject of its first half may be regarded as immunochemistry; that is, the nature of the substances involved in immunity and their interactions. It gives a full and fair account of modern knowledge; its length is justified by the need to know the substances involved and how they behave in order to understand the reactions in the living animal. Boyd now accepts the proofs that antibodies may have more than one valency, and that antigens and antibodies may build large aggregates linked by specific valencies. But his pp. 336–342 still include equations—relating the antibody/antigen ratio in the precipitates to proportions in which antibody and antigen are mixed—that assume that antibody is univalent; equations also that, unlike that of Heidelberger and Kendall, include arbitrary parameters, and do not express some of the most characteristic features of the precipitin curve.

The second part of the book is more clinical and deals with such subjects as hypersensitivity, autoimmunization and disease and immunity in action. As is inevitable when such a wide field is covered, any reader may find some detail of classification or emphasis with which he disagrees; and the presentation tends occasionally to degenerate into a list of observations and opinions with little criticism of the soundness of methods or the adequacy of grounds for opinion. But the references are there and the reader can look up the originals and draw his own conclusions.

The book ends with a chapter on laboratory methods. Two criticisms may be made. Serological methods are being applied more and more to matters outside immunity; more warning might have been given about difficulties and fallacies. Serology is not all plain sailing; it may be difficult to get antibodies against a particular antigen, and any antibody one gets may be against an impurity. Boyd might have quoted, as an example, the experiences of Cohn and colleagues and of Borduas and Grabar with ovalbumin and conalbumin. Also more might have been said about the newer techniques that are becoming popular; for example, the red-cell sensitization technique, which is merely mentioned, and the tanned-cell method, which is not mentioned at all. One can find the technique of the Wassermann reaction in many books, but not these and the Ouchterlony and Oudin methods.

Although this book will prove indispensable for research workers and advanced students, it would not help medical students and practitioners; there is too much controversial detail.

A better book for non-specialists is Carpenter's "Immunology and Serology". The author gives a clear and balanced account of modern knowledge and theories of serology. He admits that he has placed greater emphasis on serology, "partly because more is known about it". In fact, "Infection and Immunity" and "Antiviral Immunity" together get only twenty-nine pages out of the total 351; both "Allergy" and "Experiments in Serology" get as many pages. Although these twenty-nine pages give most of what is known about the defences of the individual (as opposed to external influences which should be classed under hygiene), more might have been written about the values of immunization against typhoid and pneumonia (both of which Boyd mentions) and against whooping cough, and about the role of antibodies in protection against these diseases. Discussions of protection by Salk vaccine and by diphtheria toxoid are included.

J. R. Marrack

Advances in Geophysics

Edited by H. E. Landsberg. Vol. 3. Pp. x+378. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 8.80 dollars.

THE term geophysics has become synonymous with the study of all physical aspects of the Earth. There is no better indication of this than in this series of "Advances in Geophysics" with its wide range of subjects. The third volume includes a preliminary account by A. P. Crary on Arctic ice-island research, in particular Fletcher's Ice Island (*T*3), occupied during 1952–54. Byerly contributes an excellent article on crustal structure based on seismic evidence, reviewing all work from 1900 to the present day. His discussion of the peculiarities of travel-time curves is warmly recommended to all seismologists. A third article, contributed by Bullard, Maxwell and Revelle, summarizes the progress of heat-flow measurements through the oceans' floors. One cannot avoid a sense of wonder that it is possible to measure heat-flows as small as 0·5 microcalorie per square centimetre per second at such remote places. The thermal properties of the Earth are treated on a broader basis by Jacobs in an article on the interior of the Earth. Well-logging methods, in so far as they assist in the search for ground-water, are treated in outline by Jones and Skibitzke. This article, the first of its kind in book form on the application of geophysics to hydrology, discusses the self-potential, resistivity and radioactivity logging instruments and the important part they play in ground-water investigations in the United States. There is a contribution by Sekera on the polarization of light in the atmosphere and, of current interest, an account by Singer of the experimental possibilities of artificial Earth satellites. Each author has supplied an ample bibliography with his contribution and at the conclusion of the article presents a list of the symbols used together with their explanation—a debatable practice. A number of typographical and grammatical errors occur in the text. S. H. Hall

Supplement to Mellor's Comprehensive Treatise on Inorganic and Theoretical Chemistry

Prepared under the direction of an Editorial Board. Supplement 2, Part 1: F, Cl, Br, I, At, including the Radiochemistry and Radiation Chemistry of the Halogens. Pp. lii+1153. (London and New York: Longmans, Green and Co., Ltd., 1956.) 170*s*. net.

THE first edition of the handbook of chemistry by Leopold Gmelin appeared in 1817, and the latest edition is at present in course of publication. Whether its English counterpart, the treatise of Mellor, will have such a long life, only the future can show. In most editions of Gmelin, a new one was begun before the preceding one was completed, but the editors of Mellor have adopted what is probably a better plan, of issuing supplementary volumes to bring the whole work up to date. The first of these has now been published. Although on the same plan as the original, it has some better features. Instead of the solid blocks of literature references, without any apparent organization, the present volume has numbered references to fairly short sequences, the page references to which are given at the foot of each page of the text. This makes the book very easy to use. The text is obviously based on a careful study of original sources and is more critical than Mellor's, although this has not been overdone; 'obsolete' material has a habit of coming to life again in inorganic chemistry. Numerical data, curves, and diagrams of structures are freely given, and the descriptions of experimental methods are adequate. It can safely be said that if later volumes are as good as this one, the book will be worthy of Mellor's work. The volume is quite indispensable in all chemical libraries. J. R. Partington

Solvents

By Dr. Thomas H. Durrans. Seventh edition, revised. (Volume 4 of a Series of Monographs on Applied Chemistry.) Pp. xv+244. (London: Chapman and Hall, Ltd., 1957.) 30*s*. net.

THIS is the well-known monograph to which one instinctively turns when seeking information on solvents. First published in 1930, it has now reached its seventh edition, which is sufficient indication of its usefulness and of the determination of its author and publishers to keep it up to date. The present edition retains the same general structure as its forerunners. The first part discusses the more theoretical aspects of the subject with chapters on solvent action, solvent power, plasticizing solvents, solvent balance, viscosity, vapour pressure, inflammability and toxicity; while the nine chapters in the second part deal in detail with the characteristics and uses of the individual solvents and plasticizers. Very useful appendixes give a comprehensive list of trade names with probable compositions, solubility tables and plasticizer proportions. The list of trade names now runs to more than six hundred entries and the solubility tables give information on the solubility of twenty-seven different substances such as cellulose acetate, rubber, gums and oils in more than a hundred different solvents. The volume is of convenient size and well produced. E. H. Nurse

Extraction and Refining of the Rarer Metals

Proceedings of a Symposium on Extraction Metallurgy of some of the Less Common Metals arranged by the Institution of Mining and Metallurgy, held on 22nd and 23rd March 1956, at the Royal Society of Arts, London. Pp. xviii+444+14 plates. (London: Institution of Mining and Metallurgy, 1957.) 60*s*.; 8.50 dollars.

THE subject-matter of this Symposium is one in which considerable developments are occurring, but known only to a limited number. The Institution of Mining and Metallurgy is, therefore, to be congratulated on presenting these papers and discussion to a wider audience. The papers deal with eleven of the less common metals, but uranium, vanadium, niobium and beryllium are the ones receiving most attention. Broadly, two kinds of information are to be obtained from the proceedings. On one hand, as is to be expected, there are details of processes for specific metals; on the other, there is considerable information in more general terms on the principles of various techniques, including a number of new methods, such as ion-exchange and solvent extraction for the claiming of values from leach liquors. Although the theme is predominantly chemical, there is some reference to the physical processes of ore-dressing. Apart from this specific technical matter there is revealed in a general way the considerable stimulus and development in extractive metallurgy brought about by the need for some of the newer metals and principally uranium. Moreover, it is edifying to see the position which has already been reached. A. R. Bailey

THE ROYAL SOCIETY OF CANADA

SEVENTY-FIFTH ANNIVERSARY MEETING

AT its annual meeting, held at the University of Ottawa in June, the Royal Society of Canada celebrated the seventy-fifth anniversary of its foundation. For this occasion a symposium entitled "Our Debt to the Future" ("Présence de Demain") had been organized.

The Society was founded on the initiative of the Governor-General, the Marquess of Lorne, in 1882 for "the promotion of Literature and Science within the Dominion". It is now organized in five sections: (I) Humanités et sciences sociales; (II) Humanities and Social Sciences; (III) Mathematical, Chemical and Physical Sciences; (IV) Geological and Allied Sciences; (V) Biological Sciences; and in so far as barriers between the sections can be crossed with ease, the Royal Society of Canada can contribute to the cultural life of the country by bringing together persons who have achieved distinction in these various branches of learning. It is not, like the Royal Society of London, exclusively devoted to science, and it is required to bring together men speaking two different languages with differing cultural sensibilities.

In the past few years there has evolved a new appreciation of the Marquess of Lorne's idea of the service the Society should render to Canada. It is recognized that the separate sections of the Society can no longer play the parts that are now much more effectively filled by the many associations of specialists such as the Canadian Historical Association or the Canadian Association of Physicists. The Fellows of the Society have to learn to devise new forms of intellectual intercourse to restore cultural unity in the midst of diversity of special interests, and to respond to the need of this rapidly developing country for inspiring intellectual leadership. The time for this change is appropriate, for it accompanies the institution of the Canada Council by the Parliament of Canada.

The symposium was held on the afternoons of June 10, 11 and 12 in six sessions. It was opened by Prof. D. L. Thomson (McGill), speaking on "The Roles of the Scientist and Scholar in Canada's Future" (Le rôle de l'homme de science et de l'homme de lettres à l'egard dé l'avenir du Canada), Principal W. A. Mackintosh (Queen's), president of the Society, being in the chair. Replete with pointed allusion to the Canadian scene, this address laid most emphasis on the educational processes and institutions by which scholarly and scientific influence can be brought to bear in Canadian life, and commented on current standards of values, with hope for the future of Canadian universities.

The second session, "The Penalties of Ignorance of Man's Biological Dependence" (Nos Servitudes Biologiques) was presided over by Prof. E. G. D. Murray, who recently retired from the chair of bacteriology and immunology at McGill University and will edit the book to be published for the Society by the University of Toronto Press based on the symposium. K. W. Neatby (director of Science Service, Ottawa) led off on the theme "We are not masters of our own destiny because many essential contributors to our existence, or to our destruction, are independent of man, and because of the inadequacy of our knowledge of the genetics and physiology of individual species and the complexities of biological interdependence". Prof. I. McT. Cowan (University of British Columbia) transferred the discussion from plants to animals. The problem salmon versus power on the Fraser River, B.C., evoked comment from the floor that the advent of nuclear power should save the Fraser for the salmon. Dr. G. H. Ettinger (Queen's) discussed man's internal environment, and the lone chemist participating, Dr. R. H. F. Manske (Dominion Rubber Company) concluded by suggesting that the organic chemist can probably play a larger part in coping with the biological problems than the biologists seem to think. These papers were somewhat too condensed for the general audience. The chairman summed up by saying that scientists should be less timid: they should demand and be granted more influence in the use of their knowledge, more say in the determination of financial needs for scientific research and some influence to oppose political expediency in matters affecting man's environment.

On the following afternoon Dr. N. A. M. MacKenzie (University of British Columbia) presided over the session on "The Social Impact of Modern Technology" (Conséquences sociales des progrès techniques). The sudden illness of Prof. J.-C. Falardeau (Laval University) prevented his presenting the social scientists' point of view. The session was opened by Prof. V. W. Bladen (Toronto), speaking as economist and humanist on the broad aspects of social adaptation to technological change. Dr. E. W. R. Steacie (National Research Council) emphasized that technological developments come to fruition because society wants them. Instead of laying at the door of science blame for the technical ills that afflict us, we should examine the activities of the advertising fraternity who, he had been led to believe, are products of liberal arts education. Prof. W. H. Watson (Toronto) asserted that to succeed, modern technology has to be good science, and using men for functions that cannot be performed economically by machines demands better, more responsible attitudes to work. He challenged thinkers in the universities to examine whether intellectual stimulus to-day does not lie in the field of the technologists.

The fourth session, "Our Economic Potential in the Light of Science" (Les découvertes scientifiques et l'expansion économique), presided over by Prof. H. C. Gunning (University of British Columbia), brought together a geologist, a metallurgist and two economists. Prof. J. E. Hawley (Queen's) presented our dilemma in relation to the mineral resources of Canada: although we have a debt to future generations of Canadians, we have at present one to the free world in need of raw materials. Should we attempt to conserve some or all of those we have, or alternatively can we hope to replace those we use by new discoveries? He suggested that it would be helpful to commit to a national advisory board con-

tinuing consideration of these matters. Prof. L. M. Pidgeon (Toronto) forecast the depletion of accessible deposits of rare metals and the trend towards increased use of those metals that constitute a major portion of the Earth's crust—aluminium, magnesium, iron and titanium. With the exception of iron, they are reactive metals requiring large amounts of energy to produce. This 'high-level' energy is supplied at present from water-power. The trend to remote hydro-electric locations will continue until available sites are saturated. Thereafter nuclear energy may level the cost of electrical energy throughout industrial nations. The economic consideration of mineral resources was taken up by Prof. B. S. Keirstead (Toronto) and M. Lamontagne (Ottawa) and led to some naïve questions by scientists about the technical meaning of 'capital'.

On the afternoon of June 12, the session on "Human Values and the Evolution of Society" (Les valeurs humaines et l'évolution sociale) was introduced by Father Levesque, who presided. The session was intended to bring biology and humanism together, and to this end Prof. T. W. M. Cameron (McGill) spoke about man from 'a worm's eye' view. Prof. A. S. P. Woodhouse (Toronto) made a memorable statement: "Civilization requires to be defined in terms of the good life". Education must extend its influence "from intellectual training which is its centre, to a refinement of sensibility—to the cultivation of understanding, imagination, sympathy and tolerance and to the fostering of talent and of the kind of individuality that operates harmlessly and beneficially within the framework of a free society". But he was surpassed in creating the transcendental occasion by two poets, the first, Robert Elie (Montreal), speaking in French, and the second, Roy Daniells (University of British Columbia), in English.

The closing session, "Let us Look to our Human Resources" (Recours aux forces spirituelles), was presided over by F. H. Underhill, curator of Laurier House, and opened by Dr. J. K. W. Ferguson (director, Connaught Laboratories). Trends in life expectancy in Canada and elsewhere in the world will affect us by menacing pressures of population and by modifying attitudes and aims in life. Prof. L.-P. Dugal (Ottawa) discussed the need for change in educational patterns in Canada. G. V. Ferguson (editor of the *Montreal Star*) spoke of the influence of mass media, and Dr. W. B. Lewis (Atomic Energy of Canada, Chalk River) of the efficient use of manpower with more than passing reference to the universities.

The symposium, which was open to the public, was well attended.

In the evening following the symposium, at a dinner attended by the French Ambassador and the High Commissioner for the United Kingdom, who presented messages from the French Academy and the Royal Society of London, respectively, the Society was addressed by the Governor-General, Mr. Vincent Massey. His announcement that Prince Philip had accepted the invitation to honorary fellowship in the Society was warmly received.

W. H. Watson

THE ELECTRICAL RESEARCH ASSOCIATION

NEW LABORATORIES AT LEATHERHEAD

On June 26, Lord Mills, Minister of Power, opened the Electrical Research Association's new Laboratories at Cleeve Road, Leatherhead. In his address, Lord Mills, who was welcomed by Sir Gordon Radley, president of the Association, stressed his life-long belief in the importance to Britain of industrial research. In his fifty years of participation in industry, he said, he had witnessed the peak of Britain's industrial supremacy based on the exploitation of the steam engine and had seen that supremacy challenged by other countries. These countries had tried, by intensive education and application, to overtake Britain's lead in discovery and inventiveness. Now it seemed to him that a second revolution was upon us, the age of electricity, which was changing our habits of life and our knowledge of world affairs as much as it was altering our material standards. Here then, he felt, was another opportunity which, combined with the dazzling prospects of nuclear power, should excite the imagination of young people and attract them to research and development in the electrical field. Lord Mills unlocked the doors of the main building with a gold key and the laboratories were thrown open for inspection, the principal guests being taken on a conducted tour. Altogether, about five hundred visitors and guests were present, and a similar number attended on the following day.

The site at Leatherhead, which covers about 40 acres, was acquired in 1943 when it became evident that the 1¾ acres containing the Perivale laboratories would be unable to meet the post-war needs of the Association. At that time many of the non-technical and administrative staff occupied part of the building of the Institution of Electrical Engineers in London, for which it was known that the lease would not be renewed when it expired in 1947. A scheme was prepared by the architect, Mr. H. J. Rowse, in 1946, which envisaged centralizing practically all the activities of the Association on the new site, at an estimated cost of £1 million. For certain reasons, the Council deferred implementing this plan and proposed a first stage costing £600,000, which would leave the high-power studies at Perivale and transfer the administrative staff to premises which had been acquired at Thorncroft Manor, Leatherhead. In 1950 this target was further reduced to £400,000, so that the buildings which were, in fact, erected in 1955–56 cost about £328,000 at 1946 price levels, or about one-third of the original scheme.

There are now three buildings on the Cleeve Road site, a main building (Fig. 1), a high-voltage building and a workshop. The main building contains essentially general-purpose laboratories rehousing the work and equipment which have been transferred from Perivale, where it had reached an acute state of over-crowding. It also houses a library and has a total floor area of some 48,000 sq. ft. There are three main floors, which extend through a central section

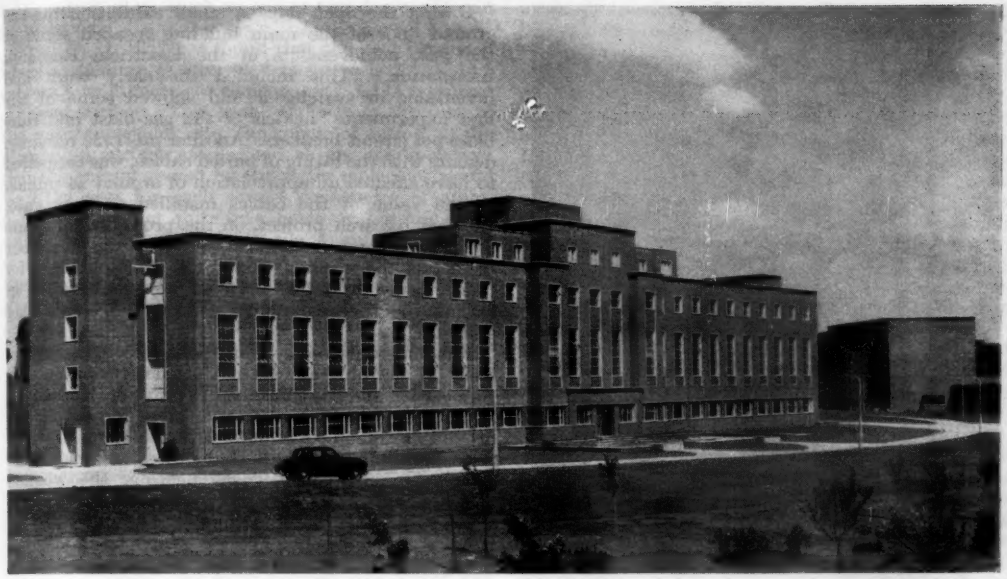

Fig. 1. Cleeve Road Laboratory, main building

and two wings north and south on the same elevation. The ground floor and the second and third floors are of normal height, while the first floor is 18 ft. high with the mezzanine floor running the whole length of the building and covering about one-third of the area. A third west wing at right angles from the central section has three floors of normal height. Altogether there are fifteen laboratories, each with a standard floor space of 50 ft. × 35 ft.

Practically all the current work in this building was shown in its natural habitat. Altogether, nearly one hundred exhibits were to be seen, varying from single pieces of special apparatus to major investigations involving considerable amounts of equipment. In the south wing of the ground floor were to be found a series of investigations concerned with the continuous and short-circuit rating of cables and the movement of moisture under thermal gradients in the soil surrounding cables. In the north wing experiments on transformers and the analysis of lightning fault statistics are carried out. Experiments on the cooling of both transformers and the buildings containing them, as well as the studies of magnetic properties of windings and core, were exhibited. The west wing of the ground floor is devoted to problems of space heating and contains a special room the surroundings of which will be under temperature, humidity and wind-speed control. Other interesting work here includes latent heat thermal storage and domestic heat pumps. The whole of the buildings at Cleeve Road are indeed being operated under close control as a space-heating study. Off-peak storage was adopted in preference to heat pumps because of difficulties and uncertainty in securing a low-temperature source. Three forms of off-peak storage are used according to circumstances. The main building uses hot water storage with circulation through a conventional radiator system; the high-voltage laboratory, where the staff and most of the equipment are to be found in the lower part of a high building, employs floor heating. Floor heating is also used in the workshops, whereas in the canteen, which is used only for short periods, block thermal storage is being tried.

A network analyser is under construction in the south wing of the first floor. Part of this is already in operation and has been used for the solution of appropriate problems, including transient stability of power systems and heat flow problems in two dimensions. The north wing of the first floor is concerned with the electric strength of solid insulation and covers some of the fundamental work on dielectrics, such as intrinsic versus electromechanical breakdown and the microscopic study of breakdown channels as well as problems of tracking and life tests in the presence of discharges. Certain service problems concerned with the vibration of overhead lines and prototype development of instruments for the non-destructive testing of insulation are also situated on this floor.

The first floor of the west wing houses those parts of the fundamental work on the electric arc which can be carried out with low power.

Ascending to the second floor, it was possible to gain some appreciation of the detailed knowledge that the Electrical Research Association has accumulated on radio interference, its measurement and control. The safety of electrical equipment in explosive atmospheres and its converse, the ignition of explosive mixtures in automotive systems, have been studied side by side for a good many years. On the same floor there is a considerable section devoted to the physics and chemistry of materials, particularly insulating materials. Quite a lot of this work is of an *ad hoc* nature, and finds one of its more basic counterparts in crystal physics in the west wing.

The high-voltage building, which is some 200 yd. from the main building in order to reduce interference, marks a considerable advance on the facilities and equipment which were available before. The surge hall has a floor area of 100 ft. × 50 ft. and is 50 ft. high. This houses a 2·8 million volt surge generator (Fig. 2) and two smaller generators of 1·3 million and 200,000 volts, respectively. It will

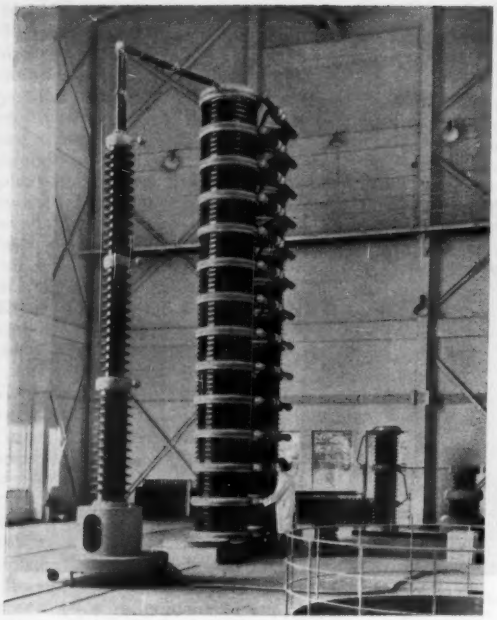

Fig. 2. 2·8 million volt surge generator

also be equipped with a 50 c./s. test transformer set of 1 million volts, a high-current surge generator and high-voltage d.c. equipment. It will thus be possible to apply all the tests required for equipment used in service at the highest supply voltages at present used or contemplated. The main hall is flanked by wings of normal height containing a transformer laboratory, generator room, instruments room, dark room and offices.

The workshop is a single-story building with a floor area of 16,000 sq. ft. It contains ample room for expansion, and at present part of it is occupied by a canteen which serves the staffs both from Cleeve Road and Thorncroft Manor.

During the open days a small exhibition on the ground floor of the main building recalled some of the past achievements of the Electrical Research Association. This included the early work and inventions in switchgear and showed some of the first experimental models of the gas-blast and side-blast pot circuit breakers. Another pre-1925 research, dealing with the rating of buried cables, was estimated to have effected an appreciation of around £4 million in the value of the cables installed at that date. Another research project, on the properties of steam at high temperatures and pressures and the behaviour of metals under similar conditions, has continued for many years, and has been of key importance in raising the thermodynamic efficiency of generating stations.

Fundamental research on dielectrics, too, started early in the programmes of the Electrical Research Association and has continued to prove of the greatest value to industry, being responsible for savings of around £1 million per annum. Other subjects included were lightning discharges and protection, radio and telephone interference, space heating, the welding arc, applications of electricity to agriculture, meter jewels, fuel cells, bomb and mine locators, the war-time work on degaussing, etc. Less tangible, but none the less of great consequence, is the service to British national and international prestige which the Association has given not only by successful contributions to research but also by the work it has done on standardization and similar committees.

These new laboratories and the space available at Leatherhead greatly enhance the facilities of the Association and should provide it with the opportunity to match the expansion which took place after the move to Perivale in 1935. Besides the sections, such as switch and control gear, which have still to be moved to the new site and for which greater facilities are required, there are many new fields of research and development in the electrical industry which have held the centre of the stage since the War and which would seem fitting subjects for co-operative research. It can be hoped that some of these will soon be included in the Association's activities.

HOW GLUE STICKS

By Dr. NORMAN A. de BRUYNE
Managing Director of Aero Research, Ltd., Duxford

MICHAEL FARADAY was keenly interested in adhesion. In 1833 he wrote: "I am prepared myself to admit (and probably many others are of the same opinion), both with respect to the attraction of aggregation and of chemical affinity, that the sphere of actions of particles extends beyond those other particles with which they are immediately and evidently in union. . . . Bodies which become wetted by fluids with which they do not combine chemically, or in which they do not dissolve, are simple and well known instances of this kind of attraction. . . . Still better instances of the power I refer to . . . are furnished by the attraction existing between glass and air, so well known to barometer and thermometer makers, for here the adhesion or attraction is exerted between a solid and gases, bodies having very different physical conditions, having no power of combination with each other, and each retaining during the time of action, its physical state unchanged"[1]. Faraday said, in effect, that glue sticks because of the unsatisfied molecular forces emanating from a surface, and nothing that has happened since has caused us to believe otherwise.

The reality of these interfacial forces can be shown in many ways, of which perhaps the most fundamental is the rise in temperature that occurs when a solid is immersed in a liquid[2]. The effect is usually small but can be easily demonstrated by using aluminium oxide powder specially prepared for chromatographic analysis to have a large surface area. When about 30 gm. of aluminium oxide are added to about the same amount of water a rise in

* The substance of a Friday Evening Discourse delivered at the Royal Institution on May 31.

temperature of as much as one or two degrees C. can be observed.

Prof. D. D. Eley has found that the heat produced when aluminium is immersed in water is $2{\cdot}7 \times 10^{-5}$ cal./cm.^{2}, or in more convenient units, 1,134 ergs/cm.^{2} of metal surface. This heat results from the rush of the water molecules into 'the sphere of action' of the aluminium surface atoms, and so one might expect that the energy gained by the water molecules would be 1,134 ergs for each square centimetre of aluminium. This is not quite true, however, because those water molecules 'bound' to the aluminium cannot move freely and their kinetic energy is taken up by the free water molecules. As a result, therefore, a slightly higher temperature will be observed than if all the molecules had shared equally in the gain of energy. It is only at absolute zero that the gain in energy equals the heat produced, because at absolute zero all the molecules will initially be at rest.

For our present purpose, which is to establish the order of magnitude, we may neglect this correction, and we can then easily write down how much work we must do to get those adsorbed water molecules away from the aluminium surface. It will be about (1,134 + 74) ergs/cm.^{2}. That 74 ergs/cm.^{2} is the additional work done in making a new water surface. Thus (1,134 + 74) or 1,208 ergs/cm.^{2} is the work required to break the joint between the water and the aluminium.

The force necessary to break one square centimetre of water–aluminium interface is obtained by dividing the work required by the distance over which the forces, due to the surface atoms, act. That distance will be about three angstroms, from which calculation shows that the stress needed to break the interface is equivalent to 584,000 lb./in.^{2}.

These interfacial forces are enormous. Even if the immersional heat of wetting is very small, as when a material like polytetrafluoroethylene (PTFE) is immersed in water, it must still be at least 74 ergs/cm.^{2}, which is equivalent to a breaking stress of some 36,000 lb./in.^{2}. Too much importance should not be attached to such figures, as Dr. Tabor has pointed out[3]; nevertheless, they indicate that the forces of adhesion need be no weaker than those of cohesion. How is it that glued joints are, in fact, so much weaker than these calculated values? This question and the possible answers to it form the substance of this article.

The problem is not so much how glue sticks, as how it is that a glue does not stick as well as it should; and how it is that a given glue will stick well to some solids and not to others; and why, if the surface forces are so strong, any glue is needed at all. Consider the last question first.

If two clean, dry, polished steel blocks are put together, why, if the surface forces are so strong, do they not adhere spontaneously? The answer is that, on an atomic scale, the surfaces are very rough and dirty. Even polished surfaces make contact at only a few places. This can be demonstrated with the surface of a glass prism displaying total internal reflexion. A rubber ball pressed to the reflecting surface shows itself as a greyish circular patch; but one of the polished steel gauge blocks pressed to the surface cannot be seen at all. The steel is in molecular contact with the glass at only a very few isolated points of molecular dimensions, whereas the rubber, which can be deformed, is in molecular contact over a somewhat greater area. The elastic energy stored up in the compressed ball is sufficient to disrupt the bonds as soon as the pressure is released. Thus, if two clean solids could be deformed plastically they would adhere, because there would then be little or no elastic energy stored up in the junctions. This can be done with soft aluminium at room temperature, as was discovered some years ago at the Research Laboratories of the General Electric Company (British Patent 644795). The surfaces are cleaned with a scratch brush, then placed quickly together and deformed locally with a punch. A good joint will result. If the cleaned surfaces are touched before the plastic deformation no adhesion takes place. That illustrates the point that surfaces must be scrupulously clean. That is a general rule in all gluing operations.

Another way in which a solid can be made to adhere spontaneously is to choose one which can be made atomically smooth. Mica can be cleaved so that it is smooth to about a few angstroms over a visible area. If we put it together again quickly it will adhere[4]. Dr. J. S. Courtney-Pratt and Dr. Anita Bailey[5] have arched up two sheets of mica, each silvered on one side, and placed the unsilvered sides in contact with their axes of curvature at right angles. By the interference fringes produced, they verified that the area of contact chosen was smooth. They found that the joint spontaneously made had a shear strength up to 14,000 lb./in.^{2}, which is as strong as the mica itself.

Because even polished metal and glass surfaces are far from smooth in an atomic sense, it is convenient to obtain contact by the use of a liquid adhesive that will run into the irregularities. This liquid is then usually, but not invariably, solidified. The effectiveness of a liquid in improving the contact between solids can be verified by pressing a wet finger on to a glass prism; the total internal reflexion will be completely destroyed.

'Pressure-Sensitive' Adhesives

Adhesives are not invariably solidified: there is a class of adhesive—the 'pressure-sensitive' adhesives—which always remain mobile. By remaining viscous, they avoid one of the causes of poor adhesion—the residual or 'locked-in' stress that is set up on solidification. On the other hand, they are never very strong, and they creep under quite a small load.

Any fluid, even air or water, can act as a 'pressure-sensitive' adhesive, as was shown in 1874 by Stefan[6], who called the effect 'apparent adhesion'. He calculated how the time of separation, t, of two disks, each of radius R, is influenced by their initial separation D, the viscosity η of the liquid in which the disks are immersed, and the normal force F applied, and obtained the equation $t = 3\pi\eta R^4/4FD^2$. The time is inversely proportional to the square of the initial separation—hence the name 'pressure-sensitive' adhesives. Stefan's measurements did not confirm this equation, but if we assume that the value of D was always greater by 15μ than his measured value, excellent agreement is obtained[7]. Stefan's analysis neglects capillarity, and is thus strictly applicable only to disks that are fully immersed in the liquid. However, if the viscosity is high, Stefan's formula can be applied to a liquid mass that fills the gap between two disks in air.

We see an example of the influence of capillarity if we first breathe on two polished steel blocks before

putting them together; they will now adhere to one another. Provided a liquid wets both adherends there will be a force of attraction between them. A water film 10^{-6} cm. thick will exert an attractive force of about one ton per square inch. These considerable forces are operating when a wetted gummed label or stamp is stuck on a wettable surface, such as clean paper or glass. But capillarity will oppose adhesion if one or both surfaces cannot be wetted; just as soon as the pressure is removed the water will push the adherends away from one another. Thus a gummed label cannot be stuck on a waxed or varnished surface[9].

Because of their low viscosity and their volatility, simple liquids such as water are not suitable materials for pressure-sensitive adhesives. In practice, such adhesives are made from highly viscous materials of complex rheological properties; the difficulty of application is overcome by applying them in solution, or as a hot melt, to a tape backing so that they wet and thus adhere firmly to the backing. They never wet other materials at room temperature because of their high viscosity. The discovery that one could roll up such a coated tape and then unroll it again was an apparently trivial observation that gave birth to a new industry. The low mobility of these adhesives prevents them from getting down into surface irregularities, but they stick tenaciously because, when an attempt is made to peel the tape off, a line of high compressive stress runs just ahead of the line of tearing. This can be demonstrated on a glass prism showing total internal reflexion, or by pulling apart two tapes that have been stuck together over a small area. As the two tapes are pulled apart, this contact area continues to run ahead of the split. This is an example of the complex way in which glued joints resist external loads.

Solidifying Glues

To make a joint strong enough to satisfy an engineer a liquid adhesive must be solidified, and this can be done in various ways. A solid, previously dissolved or dispersed in a liquid, can be allowed to dry out; this is only possible if one or both adherends are porous, as are wood or paper. To make strong joints between non-porous materials such as glass and metal, we must use a glue free from solvents. One way is to freeze a molten solid (the sealing wax technique); another way is to use a liquid the molecules of which can be made to polymerize and/or cross-link with each other *in situ*.

Whatever method of solidification is used, there is almost always some shrinkage on solidification. This is undesirable because a residual stress will be 'built in' the joint. The difficulty is overcome in glass-to-metal joints by matching the thermal contraction of glass and metal and/or by encouraging plastic deformation of the metal[9]. Since the residual stress decreases as the thickness of the adhesive layer is reduced, it is desirable to use a thin glue layer. Even polyethylene is an effective adhesive for metals if it is used in a thin layer, or if its contraction is resisted by the incorporation of sufficient glass fibre.

It is important also to make sure that the adhesive, while still liquid, runs into the irregularities of the surfaces of the adherends. This requires a glue that wets the adherends and which does not solidify too quickly. Lack of contact does not merely signify lack of glued area but, far more serious, as Dr. W. C. Wake has pointed out to me[10], it can produce cracks that will be self-propagating as soon as the external load reaches a critical value which, according to Griffith's theory, will be inversely proportional to the square root of the radius of the crack.

If an adherend has 'ink bottle' pits in its surface, that is, pits the radii of which increase with depth, then it is almost impossible to get good joints because the capillary driving pressure is so small. Such 'ink bottle' pits can be produced in wood, as Dr. M. G. M. Pryor has shown (unpublished work), where the ends of the cells have been burred over; the remedy, discovered by Mr. C. A. A. Rayner[11] before the Second World War, and which was made mandatory during the War after serious aircraft accidents, is to sand the wood first. An equally important cause of failure in gluing wood is the use of an adhesive that solidifies too slowly; a starved joint will then be produced, with most of the glue in the wood instead of at the interface[12].

The tiny air bubbles trapped by the adhesive in the surface of an adherend are probably of great significance in adhesion. The stability of such air bubbles is influenced by the shape of the pit and by the angle of contact. On a wetted plane surface the liquid will 'pinch off' air bubbles but, if the bubble makes a finite angle of contact, it can grow to quite a large size before becoming unstable. It is tedious but not difficult to compute the influence of contact angle on the shape of air bubbles trapped in pits of various kinds and sizes[13], and some of the results are shown in Fig. 1. Although these bubbles may be too small to be seen, they can be 'developed' if the liquid is previously saturated with a permanent gas and then slowly warmed up. The excess pressure inside an air bubble of radius r is $2T/r$, where T is the surface tension; as a consequence, the pressure becomes high as r tends to zero, so that formation of new air bubbles tends to be suppressed, and it is much easier for an existing air bubble to grow. This indeed proved to be the case using water saturated with air or with carbon dioxide. The growth of the bubbles is best observed by making a time-lapse

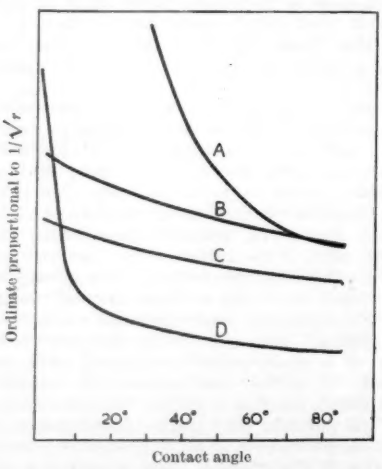

Fig. 1. Relation between contact angle and tensile stress at which progressive cracking takes place. Curve *A*, shallow spherical pit, radius 10^{-4} cm.; *B*, 45° conical pit, $r = l = 10^{-4}$ cm.; *C*, 45° conical pit, $r = l = 10^{-3}$ cm.; *D*, shallow conical pit, $r = 10^{-3}$ cm., $l = 10^{-4}$ cm. (r = radius, l = depth)

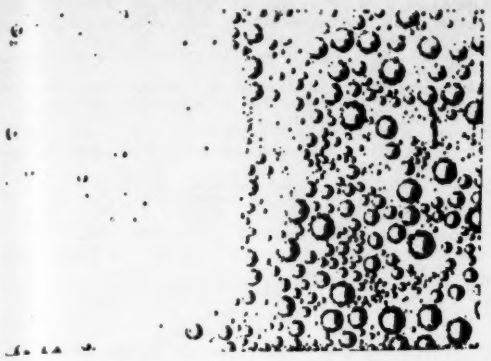

Fig. 2. Plates of polished glass (left) and polished 'Perspex' (right) lying horizontally, immersed in 'soda water'

cinematograph film. Fig 2 is a reproduction of a single frame from such a film; it shows a polished glass plate on the left and a polished 'Perspex' plate on the right lying horizontally and immersed in 'soda water'. Letters *G* and *P* had been previously marked out on the glass and 'Perspex', respectively, in the form of little conical pits. There are a few bubbles on the glass, mostly in the *G* pits and at the edges where it had been accidentally smeared with the bitumastic paint backing. The 'Perspex', on the other hand, is covered with bubbles the diameters of which reach 3 mm.

Such moving pictures provide a vivid impression of why it is so difficult to make strong joints to hydrophobic surfaces with hydrophilic adhesives, and why cavitation is so much more pronounced on a hydrophobic than on a hydrophilic surface[14], and why polytetrafluoroethylene is both such an effective anti-bumping agent in vacuum distillation of liquids[15] and such a good material for the surfaces of skis. The only way to glue hydrophobic materials such as polytetrafluoroethylene, polyethylene[16], rubber and polystyrene with hydrophilic glues is to make their surface wettable, although some of these materials can, of course, be glued together with solvents that eventually diffuse into the adherend. If lap joints between 'Alclad' strips, 1 in. wide with 1 in. overlap, are made, with an adhesive consisting of polyethylene sheet coated on both sides with an epoxy adhesive, the results shown in Table 1 are obtained.

Table 1. Strength (lb.) of lap joints made with:

untreated polyethylene	flamed polyethylene
150	920
150	600
190	650
150	780
150	800
200	750
Mean: 165 lb.	Mean: 750 lb.

Rubber can be treated by brief immersion in concentrated sulphuric acid; polytetrafluoroethylene requires immersion in a solution of sodium in liquid ammonia.

By subjecting pieces of polyethylene sheet to increasing times of immersion in chromic acid, contact angles against water can be obtained varying from about 90° to about 40°, and the joint strengths of comparable lap joints are shown in Fig. 3 plotted against the contact angle. By comparing Fig. 3 with Fig. 1, one sees that there is a similarity between the observed joint-strength and the computed value of $1/\sqrt{r}$. This gives support to the suggestion that hydrophobic surfaces make poor joints because the air bubbles act as nuclei for crack propagation.

The stresses set up in a glued joint by an external load are usually complex. For example, neither the lap joint nor the butt joint produces a uniform stress in the glue. The way that the adherends are deformed under load is just as important as the manner in which the glue behaves. That is why a given glue will give widely differing strength figures with different materials, or with different types of joint, even though rupture occurs in the glue. A review of this aspect of adhesion is given in Chapter 4 of ref. 7.

Adhesives for Metals

The application of the principles described above, as well as the availability of plastic materials that can be cross-linked or polymerized without evolution of volatiles into strong solids, has provided the aircraft engineer with quite new possibilities of construction. In thin gauges such glued joints can be far stronger than riveted or spot-welded joints. But of greater significance is the greatly improved fatigue resistance obtainable; the fatigue strength of riveted structures is much inferior to that of comparable glued structures[17]. As a corollary, the fatigue strength of riveted joints can be greatly improved by local reinforcement with a glued-on lamination.

The use of glue gives the aircraft designer a new weapon against fatigue failure and a new freedom in design. It enables him to thicken up a structure by lamination, without the expense of machining from the solid, and without fear of the rapid crack propagation to which integral structures are subject[18]. Outstanding examples of glued structures are to be found in such machines as the de Havilland 'Comet' and the Fokker 'Friendship'.

The development of strong glues for metals has also made possible a new type of construction in which two outer skins are stabilized by a honeycomb

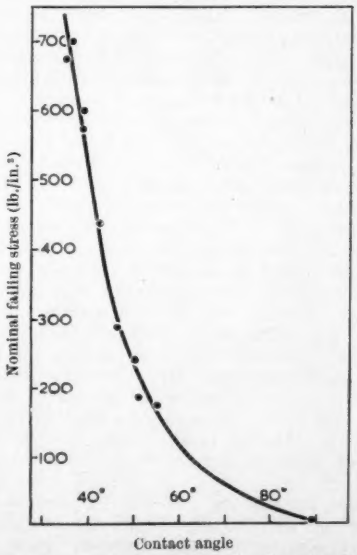

Fig. 3. Variation of tensile shear strength of 'Araldite'-polyethylene joints with contact angle (of water against polyethylene)

core of metal. This construction is of great value wherever the loads on a structure are small in relation to the required size, as in a fuselage, in the control surfaces and in the outer portions of the wing of an aeroplane. The advantages of this type of structure are a considerable gain in the ratio of strength to weight, and the complete stabilization of the skins right up to the point of collapse. A fuller account of adhesives in aircraft construction has been given elsewhere[19].

I am greatly indebted to my colleagues at Aero Research, Ltd., as well as to Dr. J. S. Courtney-Pratt, for their assistance in preparing this article. Mr. Doble, Mr. R. D. Marsh and Dr. J. T. Martin in particular helped in devising the lecture demonstrations, and Mr. G. S. Neumann assisted me both in the lecture and by his systematic preparatory work.

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OBITUARY

Dr. L. H. Lampitt

In the death of Leslie Herbert Lampitt on June 3 applied science has lost an enthusiastic and inspiring personality.

He was born in Warwickshire on September 30, 1887, and in 1908 graduated at the University of Birmingham with double first-class honours, in chemistry and biochemistry. In 1911 he became chief chemist of La Meunerie Bruxelloise, a post which he held until the outbreak of the First World War. He served with the Army in France throughout the War.

In 1919 Dr. Lampitt began what was to be his life's work, namely, the direction of the laboratories of J. Lyons and Co., Ltd. To understand the part that science could play in a great food firm required vision in those days, and the present fine laboratories and service—rapidly developed from humble beginnings under his guidance—are a tribute to the creative genius and foresight of their founder. He became a director of the firm in 1936.

Dr. Lampitt was keenly interested in new scientific and technological developments and would travel any distance to investigate new processes or to discuss mutual problems with scientists abroad. It is not surprising, therefore, that he became an international figure in the world of chemistry. He was particularly active in the International Union of Pure and Applied Chemistry, of which he had been honorary treasurer since 1945, and in the past decade he served on a number of Unesco and other international committees. He was also chairman of the organizing committees of several international scientific congresses, including that of surface activity held in London in the spring of this year. During recent years the international aspects of chemical documentation also claimed his attention.

In Great Britain, Dr. Lampitt had been honorary secretary of the British National Committee for Chemistry, chairman of the Chemical Council, chairman of the Bureau of Abstracts, and had held office in many of the scientific societies of which he was a member.

His greatest activity was in the Society of Chemical Industry, of which he was a past-president. At the time of his death, he had been honorary foreign secretary of that Society for a number of years. In 1932 he stimulated the formation of the Food Group of the Society and became its first chairman, and in 1951 he became first chairman of the Society's Overseas Section, which was also formed as a result of his enthusiasm. He was awarded the Society's Medal in 1943 and was the first recipient of the Society's International Medal in 1950. He received the Royal Society of Arts Silver Medal in 1947 and the Lavoisier Medal of the Société de Chimie Industrielle in 1950. He had held a number of lectureships and had published numerous papers on chemical and biochemical subjects.

Dr. Lampitt was a freeman of the City of London and a liveryman of the Worshipful Society of Apothecaries of London and of the Worshipful Company of Horners.

Although Dr. Lampitt was always at heart a scientist, he had a number of other interests. Hand in hand with his science went his religion. During his Brussels days he was a licensed lay reader and held office in the English Section of the Y.M.C.A.; at the time of his death he had been vicar's warden at the Church of St. Mary-on-the-Hill, Harrow, for many years.

In his younger days Dr. Lampitt was a keen sportsman, playing for his University in the football and cricket first elevens. He never lost his interest in drama, both amateur and professional, and was a devoted gardener. He took great pleasure in hospitality and was a delightful host.

Dr. Lampitt will be remembered by his friends all over the world for his humanity and good fellowship and essential kindliness, no less than for his scientific achievements. He is survived by his wife and his son.

E. B. Hughes

NEWS and VIEWS

Horticultural Chemistry at Bristol: Prof. T. Wallace, C.B.E., F.R.S.

At the members' meeting at the Long Ashton Research Station on July 17, the chairman, Capt. D. M. Wills, announced the impending retirement of the director, Prof. Thomas Wallace, after thirty-eight years service. Appointed agricultural chemist in 1919, Prof. Wallace became deputy director in 1923 and, in 1943, was made director of the Station and professor of horticultural chemistry in the University of Bristol. The best known of Prof. Wallace's many contributions to horticultural science are his studies of the effects on plant growth of deficiencies and excesses of the mineral nutrient elements. Started in his early days at Long Ashton as sand culture experiments to determine the major nutrient requirements of fruit trees and bushes, these were later to embrace all the essential elements for both agricultural and horticultural crops. His contributions in this field are epitomized in "Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms: a Colour Atlas and Guide", first published in 1943 and issued in an enlarged second edition in 1951. Prof. Wallace's position as an authority on trace-element nutrition of plants was recognized by the establishment, under his direction, of the Agricultural Research Council's Unit of Plant Nutrition (Micro-Nutrients) at Long Ashton.

Most of his research work has been concerned with problems of immediate importance to growers, and his close links with the agricultural and horticultural industries have ensured the rapid translation of his findings into practice. The acceptance of his recommendations for overcoming marginal leaf scorch by potash manuring brought into production large areas of the west Midlands previously regarded as unsuitable for fruit-growing. Among other studies with practical application were those on lime-induced chlorosis, on the classification of fruit soils, and on the effects of manurial and cultural treatments on fruit quality. Under Prof. Wallace's directorship the staff at Long Ashton has been increased threefold, while the buildings and facilities have been constantly extended. His combination of administrative capability with knowledge of horticulture has led to heavy demands for his services on committees of the Ministry of Agriculture and the Agricultural Research Council, particularly during the post-war reorganization of the research and advisory services and in the establishment of the National Agricultural Advisory Service's experimental horticulture stations. These qualities were further recognized by his appointment in 1953 to membership of the Agricultural Improvement Council.

History and Philosophy of Science at University College, London: Prof. Douglas McKie

Dr. Douglas McKie, who has just been appointed to the chair of the history and philosophy of science at University College, London, of which he is a Fellow, has been associated with that College throughout his academic life. After a distinguished career as a student of chemistry, culminating in the award of the Ramsay Medal, he was attached to the Department, of which he now becomes the head, soon after its inception under the name of "History, Principles and Methods of Science" in 1924. From that time until the outbreak of the Second World War in 1939 he was the only full-time member of the staff of the Department, the head of which was the late Prof. A. Wolf, who also occupied a part-time chair at the London School of Economics. McKie was thus intimately involved in the successive experimental stages through which the Department passed in its pioneer effort to establish a new and important subject as a regular university discipline. During the War, when the work of the Department was necessarily almost entirely suspended, he assisted in the teaching of chemistry, and on its resuscitation with a greatly increased staff in 1945, he became a reader and took a prominent part in reaping the fruits of his earlier labours. He now assumes the control of a stable and successful Department with the support of a unique experience. McKie's contributions to knowledge have been concerned chiefly with the history of chemistry and the early history of the Royal Society. He has given special attention to the work of Lavoisier, on whom he has written a standard treatise; and he is taking an active part in the publication of Lavoisier's correspondence and the identification and preservation of his apparatus.

The Royal Society of Canada

The seventy-fifth anniversary meeting of the Royal Society of Canada was held in Ottawa during June 10–12. A symposium on "Our Debt to the Future" occupied each afternoon, and the final address was given by His Excellency the Governor-General at dinner on the evening of June 12 (see p. 259 of this issue). Sections of the Society held meetings in the morning only. Section III (Mathematical, Chemical and Physical Sciences) held a symposium on "Symmetry", introduced by its president (Prof. H. S. M. Coxeter), who discussed crystal symmetry and its generalizations. Section IV (Geological Sciences) met under the presidency of Prof. H. C. Gunning and held a symposium on "Hydrology". Section V (Biological Sciences) was addressed by its president, W. H. Cook, on "Research in the Biosciences: a Mid-Century Perspective", and by Prof. T. W. M. Cameron on "Parasitology and the Arctic"; a post-humous paper by Prof. G. Lyman Duff on the "Etiology and Pathogenesis of Arteriosclerosis" was also presented.

Officers of the Society for the year 1957–58 were elected as follows: *President*, Prof. T. W. M. Cameron; *Vice-President*, Pierre Daviault; *Hon. Secretary*, C. P. Stacey; *Hon. Associate Secretary*, Guy Sylvestre; *Hon. Treasurer*, N. E. Gibbons; *Hon. Editor*, G. W. Brown; *Hon. Librarian*, W. K. Lamb. Officers of the scientific sections are as follows. Section III: *President*, Leo Marion; *Vice-President*, Prof. G. M. Shrum; *Secretary*, Prof. A. D. Misener. Section IV: *President*, H. C. Rickaby; *Vice-President*, L. S. Russell; *Secretary*, S. C. Robinson. Section V: *President*, Prof. W. R. Campbell; *Vice-President*, N. H. Grace; *Secretary*, J. Gibbard.

Council for Overseas Colleges of Arts, Science and Technology

As announced in an answer on August 1 to a question in the House of Commons, the Council for Overseas Colleges of Arts, Science and Technology has been formed to replace the existing Advisory Committee on Colonial Colleges of Arts, Science and Technology. The Advisory Committee was set up

in 1949, and has since then fostered the development of the Royal Technical College of East Africa in Nairobi—which was officially opened by Princess Margaret last October—of the Nigerian College of Arts, Science and Technology with branches in the three regions of Nigeria, and of Kumasi College of Technology, in Ghana. It has also assisted with the development of Fourah Bay College in Sierra Leone, and with the setting-up of the Singapore Polytechnic. The Committee is advising on the establishment of technical colleges in the West Indies. As Advisory Committee on grants for higher technical education under the Colonial Development and Welfare Acts, it has always worked in close contact with the Colonial Office.

The chairman of the new Council is Sir David Lindsay Keir, master of Balliol College, Oxford, who was chairman of the Advisory Committee. Its other sixteen members, who were also members of the Advisory Committee, include prominent educationists with wide experience of education in the overseas territories and leading figures in the field of technical education in the United Kingdom; provision has also been made for three co-opted members to be added to the Council. Payment for the Council's secretariat and overhead expenses is made largely from Colonial Development and Welfare funds. The main function of the Council is to advise the Secretaries of State for Commonwealth Relations and for the Colonies, overseas governments, governing councils of overseas colleges and other interested organizations on the development of colleges of arts, science and technology. These are defined as colleges which offer courses of general, scientific and technical education leading to professional or near-professional qualifications (not, normally, university degrees) and which encourage research—including colleges which offer, in addition, courses of a lower standard. It will be ready to assist in the recruitment of staff, and to advise on matters of academic policy. It will also seek to stimulate the interest of technical and other institutions in the United Kingdom in the overseas colleges, and to assist examining bodies and professional institutions in Britain on courses, examinations and qualifications specially designed to meet the needs of overseas students. To avoid duplication of effort, the Council will maintain close liaison with the Inter-University Council for Higher Education Overseas and with the Colonial University Grants Advisory Committee. It will also maintain close liaison with the Advisory Committee on Education in the Colonies, with the object of relating the work of the Colleges to that of other educational institutions, particularly those giving trade and technical training.

The Journal of Solar Energy Science and Engineering

Publication of a new journal intended to cater for the growing interest in practical developments of the utilization of solar energy (*Journal of Solar Energy Science and Engineering*. Pp. 64. Subscription rate: 10 dollars per year. Phoenix, Arizona: Association for Applied Energy, 1957) commenced in January as one consequence of the First World Symposium on Applied Solar Energy held in Arizona, 1955. The first issue contains articles describing a wide range of solar energy applications. Variation of solar radiation and an analysis of the effects of season and orientation of the Sun; latitude, altitude and cloudiness at the place of reception are the subjects of two papers of importance in assessing the potential value of heat collectors. A contribution from Russian scientists describes experiments in the U.S.S.R., and the projected design of a solar boiler of steaming capacity about 12 tons per hour. Other papers are concerned with photosynthesis, the design of solar furnaces and the production of cold by solar radiation. A review of world research activities on solar energy and abstracts from the literature forms a useful guide to present developments.

Volume 1, Nos. 2 and 3, published in July 1957, have been combined as the Proceedings of the 1957 Symposium at Phoenix on Solar Furnaces. A collection of twenty papers describes various applications, the principles of design and methods of control, industrial and economic factors in their use. The present largest mirror, 35 ft. in diameter, is at Montlouis in the Pyrenees, under the direction of M. Felix Trombe, but mirrors up to 100 ft. in diameter are being designed by the Stanford Research Institute. These solar furnaces are used mainly for research on the properties of materials at temperatures up to 3,000° C., and in some cases are linked with research on high-velocity rockets and nuclear developments. This valuable survey indicates that solar furnaces have many research applications in localities where solar radiation is intense, but the development of these for routine manufacturing processes is still a matter for the future.

Tower for Optical Testing

The manufacture of telescope mirrors requires extensive optical testing of the reflecting surfaces. In the past this has been performed in a horizontal tunnel with the mirror standing on edge. This method proved satisfactory for mirrors of moderate size, but for very large mirrors a still better technique was desired. The use of a horizontal tunnel has the disadvantage that the mirror in its cell is not supported in the same manner as it would be in the completed telescope. To overcome this difficulty, Sir Howard Grubb, Parsons and Co., Ltd., of Walkergate, Newcastle upon Tyne, have constructed a tower, 100 ft. high, for the optical testing of large mirrors. The mirror under test is supported horizontally at the bottom of the tower. A number of floors at various heights inside the tower provide access to the optical axis of the mirror; each floor has a central hole through which the light beam may pass. Special precautions are being taken to ensure constant temperature conditions inside the tower.

International Abstracts of Biological Sciences

Last October it was announced (see *Nature*, 178, 726; 1956) that the Council of Biological and Medical Abstracts, Ltd., proposed to change the name of *British Abstracts of Medical Sciences* to *International Abstracts of Biological Sciences*. This change has now occurred, and it emphasizes two important developments in the character of the journal. The abstracts now include a wider range of subjects and they also cover the Russian literature. The inclusion of subjects not previously covered has been promoted by the appointment to the Council of representatives from the Society for Experimental Biology. A variety of other improvements have also been incorporated, and *International Abstracts of Biological Sciences* now provides a comprehensive abstracting service for the experimental and biochemical aspects of biology. The journal is published by the Pergamon Press for

the Council on a non-profit-making basis. All inquiries, and offers of help in abstracting (especially from those with a knowledge of Russian), should be addressed to the Editorial Offices, *International Abstracts of Biological Sciences*, Pergamon Press, Ltd., 4–5 Fitzroy Square, London, W.1.

British Museum (Natural History)

More than two hundred years ago Hans Sloane bequeathed his famous collection representing all branches of natural history, as well as manuscripts, coins and antiquities, to the nation. From this collection, the Cotton Library and the Harley collection of manuscripts, grew the British Museum. Before the Museum was a century old it had grown so big that the removal of the Natural History Departments to another site was inevitable; in 1881 the British Museum (Natural History) was opened to the public. To-day the Museum has nearly four acres of gallery space in which exhibits are set out in a form which makes nonsense of the dry-as-dust aura so often attributed to museums. A short guide to the exhibition galleries has recently been published (pp. vi+30. London: British Museum (Natural History), 1957. 1*s*. 6*d*.), which not only helps the visitor to find his way around the Museum but also helps him to see how the Trustees are constantly changing the Museum's face to meet changing conditions. In the Central Hall, for example, preparations are now being made for a series of exhibits to explain evolution. In the Mineral Gallery and Balcony a special exhibition in connexion with the current antarctic expeditions and the International Geophysical Year shows examples of rocks collected by earlier antarctic expeditions; conditions of life and work in the antarctic are also illustrated.

Science in Burma

Part of the Four-Year Plan for Education in Burma is a scheme for the improvement of science teaching. This includes the formation of science clubs to stimulate out-of-school interest and the preparation of exhibitions for schools. Science advisers who run clubs in three high-schools, two in Rangoon and one in Taunggye, have recently received gifts from the Asia Foundation in the United States of radio transmitters and receivers, model telephones, model steam engines, instruments to measure humidity and astronomical charts. The gifts were received by U. Kaung, director of education in Burma. Encouragement in setting up the science clubs has been given by members of the Unesco Technical Assistance team in Burma.

Sheffield Interchange Organization

At the recent annual general meeting of the Sheffield Interchange Organization (SINTO), which is responsible for the pooling of scientific literature in the Sheffield area, it was reported that a recent survey had revealed 4,500 files of scientific journals in the thirty-nine co-operating libraries, covering 2,500 separate titles. Members agreed to amalgamate some of the duplicated files so as to save space and binding costs. Three new research bibliographies were produced during 1956–57 by the Science and Commerce Department of the Sheffield City Libraries. These were No. 62, "The CO_2 Process"; No. 63, "The Strength of Single Metal Crystals"; and No. 64, "Ceramic Tools". Use made of the interlending facilities continues to increase, and last year members lent to each other 3,272 items. While the Science and Commerce Department continues to lend most of these publications, research and institutional libraries in Sheffield lent 886 items compared with 559 items in the previous year.

Morphology and Cytology of Linseed Autotetraploids

Induced autotetraploids of three strains of linseed, *Linum usitatissimum* L., have been studied by K. K. Pandey (*Lloydia*, 19, 245; 1956) to observe their comparative morphological and cytogenetical behaviour. Considerable differences in the fibre bundles of diploid and tetraploid strains were noted, the latter being commercially inferior. A conspicuous difference in reciprocal crosses of tetraploids is thought to be due to the incompatible genetical constitution of the female parent. Crosses between $2n$ and $4n$ plants showed that they were highly incompatible. This is of great economic significance as it ensures the purity of the tetraploid strains. In cytological studies about 47 per cent of the tetraploid plants were found to be aneuploids. In studies of meiosis, various irregularities were observed. Of the aneuploids, only 58-chromosome plants produced a few seeds. Among the factors considered to be jointly responsible for sterility in tetraploid linseed were meiotic abnormalities in pollen mother cells, failure of embryo-sacs (70 per cent) to attain a fully mature, 8-nucleate stage at fertilization, presumed defective anther dehiscence (about 10 per cent) which makes self-pollination difficult, failure of the apparently fertile pollen grains to germinate, and abnormalities in a large proportion of the pollen tubes, many of which burst or aborted during their way down the style.

International Lunar Society

For many years amateur astronomers have been interested in selenographical studies, and many astronomical societies have lunar sections. The International Lunar Society was founded in 1956 with the object of co-ordinating the work of lunar observers. Dr. H. P. Wilkins is the first president of the new Society. A journal, *Revista de la Sociedad Lunar Internacional* (International Lunar Society, Secretary, Prof. Antonio Paluzie-Borrell, Diputacion 337, Barcelona), is to be published at intervals of six months. The first issue, which appeared in March, contains five articles on various aspects of selenography. The articles in the *Revista* are in English, with summaries in French, German and Spanish.

"Regard the Earth"

Schools, and secondary school pupils in particular, will be especially indebted to Dr. R. Fraser and to the Science Club for the inexpensive but excellent and comprehensive account of the International Geophysical Year which has been published under the title "Regard the Earth" (Pp. 24. London: Science Club, 5 Great James Street, W.C.1, 1957. 2*s*. 6*d*.). The International Geophysical Year began on July 1 and will last for eighteen months. During this time scientists from some fifty-five nations will be engaged in a great co-operative enterprise to make an extensive and complex exploration of man's environment, of the Earth's atmosphere, crust and core. The work has been divided into ten main sections: meteorology, oceanography, glaciology, ionospheric physics, geo-

magnetism, the aurora, cosmic rays, seismology, gravity, and latitudes and longitudes. Without a trained guide it may be difficult to grasp the essential aims and the methods to be employed in the international project. As administrative secretary of the International Council of Scientific Unions, the body which is responsible for the organization of the Geophysical Year, Dr. Fraser is probably unequalled in the capacity of such a guide, and "Regard the Earth", the small, illustrated guide book which he has written, clearly explains why 1957–58 was chosen for the project and what exciting activities and results are to be expected. The booklet is an excellent introduction to the more detailed scientific account and is strongly recommended to all school libraries.

Department of Northern Affairs and National Resources: Appointments

The following appointments in the Canadian Department of Northern Affairs and National Resources are announced: Dr. I. C. M. Place, a Canadian forester who has been engaged in teaching and research at the University of Wisconsin, Madison, since 1955, to be officer-in-charge of the Petawawa Forest Experiment Station of the federal Forestry Branch; and Dr. J. S. Rowe, senior research officer at the Winnipeg office of the federal Forestry Branch, to co-ordinate all ecological studies carried out by the Branch's forest research division. He will be based at Branch headquarters in Ottawa.

British Oxygen Fellowship Awards

British Oxygen Fellowships for postgraduate research have been awarded to the following: J. W. Arnold, for research in the Department of Chemical Engineering at the Imperial College of Science and Technology, London; R. K. MacCrone, of the University of the Witwatersrand, Johannesburg, for research in the Clarendon Laboratory, Oxford; and J. B. Thompson, for research in the Department of Physics, University College, London. Renewal of fellowship for a third year has been granted to R. A. H. Pool, to continue research in the Inorganic Chemistry Laboratory, University of Oxford.

Paul Instrument Fund Committee Awards

The Paul Instrument Fund Committee has awarded the following grants: £2,075 to Dr. E. T. Hall, senior research officer at the Research Laboratory for Archæology and the History of Art, Oxford, for the construction of an apparatus with which magnetic measurements may be made of archæological material and for the development of an instrument for applying the method of neutron activation analysis to archæological problems; and £2,600 to Dr. C. N. Smyth and Mr. F. Y. Poynton, working at the Northampton Polytechnic, London, for continuation of the construction of an ultrasonic microscope for which a grant was made in December 1954.

The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Announcements

Dr. Fritz A. Lippmann, who received a share of the Nobel Prize for medicine and physiology in 1953 for his work on coenzyme A, has been appointed member and professor of the Rockefeller Institute for Medical Research, New York.

Prof. W. C. Stadie, professor emeritus of research medicine in the University of Pennsylvania, has been awarded the Alvarenga Prize for 1957 by the College of Physicians of Philadelphia, for his major contributions to knowledge of carbohydrate metabolism.

The Low Temperature Group of the Physical Society and the Institution of Chemical Engineers are jointly organizing a one-day conference on "Recent Developments in Industrial Low Temperature Gas Separation", to be held on November 26 at the Royal Institution, Albemarle Street, London, W.1. Further details can be obtained from the General Secretary, Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

The twelfth National Conference of the British Institute of Management, with the theme "Research —a Signpost to Better Management", is to be held in Bournemouth during November 6–8. The discussion will fall under the main headings of general management, human relations, production, economics, marketing, office management and finance. Inquiries should be addressed to the Conference Office, British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4.

The annual conference of the Society of Leather Trades' Chemists will be held in the large Chemistry Lecture Theatre, University of Leeds, on September 27 and 28, when K. B. Ross, director of operations in the Industrial Group of the United Kingdom Atomic Energy Authority, will deliver the Society's sixtieth anniversary lecture, on "Some Reflexions on the Atomic Energy Industry". Inquiries should be addressed to the honorary secretary of the Society, G. H. W. Humphreys, Forestal Central Laboratories, Harpenden, Herts.

The second conference on "Pulverized Fuel", organized by the Institute of Fuel, will be held at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1, on November 27–28. This conference is intended to review developments in pulverized-fuel firing since the first conference in 1947, and to set the subject in focus against the general background of development in all fuels, including nuclear fuels. Advance copies of papers will be sent to those enrolling with the Secretary, Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1, to whom all inquiries should be addressed.

The fourth Conference of the International Society of Soil Mechanics and Foundation Engineering will be held at the Institution of Civil Engineers, Great George Street, London, S.W.1, during August 12–24. The papers to be delivered, which have been preprinted in two volumes of Proceedings, are to be discussed in nine sessions, including soil properties and their measurement; techniques of field measurement and sampling; foundations and structures; roads, runways and rail-tracks; earth-pressures on structures and tunnels; and earth dams, slopes and open excavations. Inquiries should be addressed to the secretary, A. Banister, c/o Institution of Civil Engineers, Great George Street, London, S.W.1.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

ANNUAL REPORT

THE chairman of the Council of the British Electrical and Allied Industries Research Association, Mr. F. H. Bramwell, refers in the opening paragraph of his foreword to the annual report of the Association to the loss sustained in the death a little more than a year ago of its director, Dr. Stanley Whitehead. Dr. Whitehead's successor, Dr. H. G. Taylor, took up duty on May 1, 1957, the day of the annual general meeting of the Association.

During the year under review, the Association has transferred the major part of its research activities to new laboratories at Leatherhead, which were formally opened by Lord Mills, Minister of Fuel and Power, on June 26 (see p. 260 of this issue).

The list of reports issued during the year represents all but one of the twenty sections into which the Association's work is divided. Much effort continues to be devoted to work on dielectrics, but it is stated that increasing pressure on the Association to extend its investigations to cover new dielectric materials and processes is tending to reduce the scale and scope of the fundamental work on dielectrics, much of which served in earlier years as the foundation upon which the present developments were based. Intensive study is being given to the factors determining the electric stress at which discharge is initiated in void-free impregnated dielectrics. Work is continuing on the revision of intrinsic electric strength measurement following the discovery, previously reported, of electro-mechanical breakdown. A new investigation is in progress to test a hypothesis suggested by the results of life-tests on paper dielectric capacitors, namely, that one of the factors limiting life is a distribution of weak spots in the dielectric much larger than that corresponding to the known number of conducting particles.

Progress is reported in theoretical work on electronic emission from the metal cathode of an electric arc. The spark discharge in uniform fields is being investigated in relation to formation times by means of a new technique in which a stabilized d.c. supply is used to energize an impulse generator. Further work on gas breakdown at ultra-high frequencies has included measurements in sustained oscillatory fields.

Work on the ratings of transmission and distribution cable includes an extensive programme of field-tests designed to produce data which will enable the fullest utilization of cables to be attained. One aspect of the investigation is the determination of moisture displacement and consequent drying out in the vicinity of loaded cables and the resulting reduction in heat dissipation.

Practical progress in circuit breakers and contactors has resulted from the work on circuit interruption at high vacuum. Work on air-blast circuit breakers has included the study of the voltage distribution across gaps in series in multi-break circuit breakers. Fundamental theoretical work on the electrical and thermal processes of the steady-state arc has suggested that higher arc temperatures occur than had previously been supposed. These predictions, which have been confirmed by spectrographic measurements, have important consequences in relation to the dynamic behaviour of arcs in switchgear.

Progress is reported in the several branches of work on flame-proofness and intrinsic safety. Among these may be mentioned measurements made simultaneously at four points of the transient pressure associated with explosions in the 800 h.p. motor at the Safety in Mines Research Establishment, the machine running at normal speed.

Work continues on the extension of steam tables to 750° C. and 15,000 lb./sq. in., and it is noted that these researches provided a substantial contribution to the Fifth International Conference on the Properties of Steam held in London in July 1956. The programme of work on the creep and corrosion resistance of steel for high temperatures continues, and mention is made that the test rig for the investigation of steampipe welds which was being installed at Brimsdown power station is now in operation.

The Association has long been concerned with work on electrical interference. The authoritative work on inductive interference which has been in preparation for some time is now in process of publication.

In the field of rotating machines, a new theory of tooth ripple flux penetration into laminated pole faces has been developed and has been substantially confirmed by experiment.

The analysis of the behaviour of power systems under steady-state and transient conditions will be greatly facilitated by the completion of the network analyser which is now in partial operation in the new laboratories.

It is interesting to note in passing that the one section of the Association's work not represented by publications is that dealing with the transmission of power at high voltages. Much of the activity of this section has been devoted in recent years to studies of high-voltage direct-current transmission. This work had been in abeyance during the past year, but it may well be that the decision to utilize high-voltage direct current for the cross-Channel power link with the Continent will revive activity in this field.

It is noteworthy that, at the beginning of the report, mention is made of possible future restriction of the Association's development in the absence of increased financial support from industry. The opening of the Association's new laboratories should provide a powerful stimulus to the industry to give increased support to the work of an association which, during the past thirty years, has made a major contribution to the advancement of knowledge and to practice in the electrical engineering field.

J. GREIG

FORESTRY IN THE COMMONWEALTH

THAT forestry, as a serious piece of administration, has been taken up by the British, the annual forestry reports for the Dominions, Colonies and former Colonies or Protectorates give full evidence. As instances, the report of forest administration for 1954–55 for the Western Region of Nigeria (pp. ii+28. Lagos: Government Printer; London: Crown Agents of Oversea Governments and Administrations, 1956. 9*d*.), and those of the Federation of Malaya, British Guiana and the Sudan may be quoted. From the forestry point of view, the division of Nigeria into three separate regions is unfortunate, since forestry management will become more costly, and for the country as a whole may become more difficult. In a foreword to the report, the Minister of Agriculture deplores the scarcity of suitably educated young Nigerians to fill posts in the Department, and he expresses the hope that the educational facilities at present available will produce candidates capable of taking a forestry degree at a university. A new and important departure is being undertaken in the development of small plantations carrying both timber trees and an under-crop of cocoa or rubber, a notable piece of work which will require a fully trained staff for its supervision. It has recently been decided (Federation of Nigeria. Annual Report on Forest Research and the Forest School, 1954–55. Pp. 16. Lagos: Federal Government Printer, 1957. 9*d*. net) that all aspects of forestry research in Nigeria should be the concern of the Federal Department of Forestry and the application of such knowledge should be the concern of regional departments, the latter being accorded permission to engage in whatever research they desired in accordance with funds available.

The report on the Federal Forest Administration of the Federation of Malaya for 1955 (by D. S. P. Noakes. Pp. ii+93+6 plates. Kuala Lumpur: Government Printer, 1956. 2 Malayan dollars; 4*s*. 8*d*.) is of considerable interest. In spite of the internal troubles of the past years, the Forest Department has been able to proceed with its work, as the first part of the report well shows. It deals with the operations of the Federal Section of the Forest Department, which embrace research, education, engineering (forest), departmental trading in forest produce, local timber supplies and the export trade. The second part treats of the departmental work throughout the Federation.

The report of the Forest Department, British Guiana, for 1955 (pp. 32. Georgetown: Government Printer, 1957) shows the Department still in a difficult stage of progress due to the shortage of senior staff. A development programme is shortly to be introduced, but only one scheme of the Central Timber Manufacturing Plant has proceeded according to plan. It would appear that the most important part of the planning would be for the training of staff for sylvicultural work in the forests. The report for the Sudan (Ministry of Agriculture: Forests Department. Report for the period July 1954 to June 1955. Pp. iv+75. Khartoum: Department of Forests, 1956) owes much to the work of the former British forest officer. As regards forest policy, the introduction of control of fellings formerly made at will by the population of the country, the prohibition of felling in forest reserves without a licence, and control of fellings for village needs are to the good. These are departures which are essential in the interests of so arid a country as the Sudan and perhaps a native administration has found it easier to introduce them.

The activities of the Forest Research Institute of New Zealand (New Zealand Forest Service. Annual Report of the Forest Research Institute for the year ending 31 March, 1956. Pp. 88. Wellington: Government Printer, 1956) have made continued progress, and two major objectives have been achieved in the completion of field-work for the National Forest Survey of production forests and the formation of the Forest Biology Survey. Sylviculture members of the staff appear to be deficient, a curious anomaly, since sylviculture is the basis of the whole of forestry practice. Requests from conservancies for advice and assistance prove the value of the Institute.

During the past few years, research in forestry subjects has made an impressive advance. If we look to New Zealand, Canada, Australia and South Africa, India, Nigeria, the Sudan, and many other of the smaller forest services, most publish regularly the results of their researches, a service which is of great importance to the progress of forestry and its beneficial influences on mankind as a whole.

THE PHYSICAL SOCIETY

REPORT FOR 1956

THE report of the council of the Physical Society for the year ending December 31, 1956, together with the report of the honorary treasurer and the accounts and balance sheet, were presented to the annual meeting of the Society held at the Science Museum, London, on June 4, and adopted, and the composition of the new council for 1957–58 announced. At the extraordinary general meeting which followed, approval was given for amendments to the articles and rules of the Society to enable the council to elect Fellows without submission of their names to science meetings of the Society.

Immediately afterwards, Prof. N. F. Mott delivered his presidential address entitled "The Physics and Chemistry of Metals", in which he described how physical techniques are contributing to an understanding of the nature of the metallic bond. Measurements of diamagnetism and of conductivity at high frequencies and low temperatures enable an experimental determination to be made of the form of the Fermi surface, which indicates how much the form of the electronic wave functions varies with direction. The behaviour of the magnetic electrons in nickel and iron was contrasted. In nickel the *s* and *d* bands overlap and both contribute to the Fermi surface; in iron the magnetic electrons do not contribute to the Fermi surface or to the conductivity. Finally, the effect of chemical or binding forces on mechanical properties was discussed.

The report comments on the way in which the form of the Society's science meetings has altered in the past few years, from meetings devoted to the reading of papers submitted for publication in the Society's journals to short conferences on specific subjects at which papers are presented bearing on aspects of the subject but not necessarily describing work sufficiently advanced for publication. Four such conferences were held during the year: "Cloud

Physics", jointly with the Royal Meteorological Society, during January 4–5; "Semiconductors", in conjunction with British Thomson-Houston Research Laboratories, during April 10–12; "The Physics of Gas Flow at Very High Speeds", at the University of Manchester, during July 16–17; and "β- and γ-Ray Spectroscopy and Related Topics", at the University of Edinburgh, during December 17–19. It is planned to hold six or seven conferences annually. The arrangement to hold joint colloquia on electron physics open to members of the Institute of Physics and of the Society was continued, and two meetings were held. The annual Fellows' luncheon, which was attended by about one hundred Fellows, was again held on the opening day of the annual exhibition of scientific instruments and apparatus. The fortieth Guthrie Lecture was delivered by (the late) Sir Francis Simon, who gave a historical survey of the third law of thermodynamics, and the eighth Rutherford Lecture by Prof. P. I. Dee, who spoke on the alpha particle.

Prof. J.-P. Mathieu was the recipient of the eleventh Holweck Medal of the Société Française de Physique and the Holweck Prize of the Physical Society; after the presentation, which took place in London, Prof. Mathieu delivered the Holweck discourse on the subject of crystalline structures. Prof. J. G. Daunt (Ohio State University) received the thirty-third Duddell Medal and for his address discussed the magnetic refrigerator for temperatures below 1° K. (now published in *Proc. Phys. Soc.*, B, **70**, 641; 1957). The twelfth Charles Vernon Boys Prize was presented to Prof. G. D. Rochester and Dr. C. C. Butler in recognition of their work on the discovery of the charged and uncharged *V*-particles.

During 1956, the Council states, there was a slight increase in the total membership, from 1,978 to 1,999. There was an overall surplus for the year of just over £1,000, indicating the healthy condition of the Society's finances, and this is emphasized by the balance sheet, which shows that the Society's investments, apart from special funds, total more than £20,000. Expenditure on behalf of the members exceeded income by about £700, and on general activities, consisting mainly of publications and science meetings, the Society incurred a loss of nearly £1,200 in spite of a generous grant of £1,500 from the Royal Society. However, as in former years, the annual exhibition of scientific instruments and apparatus, through the success in sales of the handbook to the exhibition, brought in a revenue which more than counterbalanced the losses. Both halls of the Royal Horticultural Society were used for housing the exhibition. The number of exhibitors was substantially the same as in previous years and the attendance was again large—more than 16,000.

Greatly increased interest in the Society's publications during the year is reported. The sale of the current numbers of both the *Proceedings of the Physical Society* and the "Reports on Progress in Physics" has risen, and there has been a large increase in the sale of earlier volumes of the "Reports" and of some of the Society's special reports, particularly the 1954 Bristol conference report on "Defects in Crystalline Solids" and the 1954 Cambridge conference report on the "Physics of the Ionosphere". A serious delay because of printing troubles in the publication of the *Proceedings* during the earlier part of the year has since been made up. Two hundred papers and 111 research notes and letters were accepted for publication; 45 were rejected or withdrawn by the authors. Vol. 19 of the "Reports", containing nine specialist articles, was issued during the summer and separate copies of the individual articles were again available for purchase.

Details of the activities of the four Groups of the Society, the Colour, Optical, Low Temperature and Acoustics Groups, together with a list of the numerous bodies on which the Society is represented, are given in the annual report. In addition to science meetings, the Optical Group held its summer meeting at the University of Exeter; the Low Temperature Group held an all-day discussion meeting on the subject of liquid helium, and a two-day joint conference with the X-ray Analysis Group of the Institute of Physics at the Clarendon Laboratory, Oxford, on the subject of X-rays and low-temperature crystallography, and visited the Low Temperature Laboratories of the Royal Radar Research Establishment, Great Malvern; and the Acoustics Group included in its programme a symposium on loudspeakers and a distinguished visitor's address by Dr. W. E. Kock.

The officers and council for 1957–58 are as follows: *President*, Prof. N. F. Mott; *Vice-Presidents* (in addition to those who have filled the office of president), Prof. S. Devons, Prof. F. Llewellyn Jones, Prof. H. Jones and Dr. K. Mendelssohn; *Honorary Secretaries*, Dr. C. G. Wynne and Dr. H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, Mr. A. J. Philpot; *Honorary Librarian*, Dr. R. W. B. Pearse; *New Ordinary Members of Council*, Dr. B. H. Flowers, Prof. M. H. L. Pryce and Mr. E. W. H. Selwyn.

WATER POLLUTION RESEARCH

THIS review of the report of the Water Pollution Research Board for 1956* could start with a frequently quoted verse from Gray's "Elegy" about gems and flowers, though some might find odd the juxtaposition of any thought from that poem and sewage. The point is that this publication is of a kind liable to be ignored by most not directly concerned with pollution on the grounds that it is of interest only to those who are, which is not true. The reviewer deems it his function to show where and why this is not true even if, in dwelling on those pieces of research that will command interest outside the applied field, he gives an unbalanced picture of the work of the Laboratory.

The concentration of oxygen is one of the important factors affecting freshwater organisms, but one of which the significance is very hard to assess because it often fluctuates considerably and often reaches critical values at the most inconvenient times of day. Any method of recording it continuously will be welcomed by many concerned with both theoretical and applied problems; the Water Pollution Research Laboratory has devised two. The first required mains electricity which limited its range rather seriously. The second, referred to in the report under review, can be operated from batteries.

The results of what must clearly have been an extensive series of trials are summarized in a table which shows at three temperatures the highest concentration of oxygen at which all fish died in a week and the lowest at which all survived for a week. Most oxygen was required at the highest temperatures,

* Department of Scientific and Industrial Research. Water Pollution Research 1956: the Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory. Pp. iv+75+4 plates. (London: H.M. Stationery Office 1957. (4s. net.

and rainbow trout generally needed more than any of seven species of coarse fish tested, which is just what anyone would have foretold. Other results are more unexpected; for example, trout survived for a week at a temperature of 20° C. when the concentration of oxygen was only 29·6 per cent of saturation, and the most exigent species at this temperature was mirror carp, which required 58·9 per cent. Another surprise is the smallness of the difference between the two figures; at 20° C. the oxygen concentration had only to drop to 28·2 per cent of saturation and no trout survived for a week. There is much in this table for physiologists, ecologists and those charged with the care of fishing waters.

The aerating effect of weirs has been studied, and it has even been possible to find a formula for it.

The rest of the report will interest mainly those directly concerned with pollution problems. An extensive survey of the Thames estuary has been made to discover the amount of oxygen that combines with polluting matter and the amount taken by the water from the air, together with the influence of temperature, rate of flow and tidal phenomena on these two processes. The hope was that it might be possible to find general principles from which the effect of the last three on the first two could be predicted. An observer knowing the rate of flow, the temperature, and the state of the tides, which are easily measured, could then say how much polluting matter could be discharged into the stream without causing total oxygen deficiency and nuisance anywhere. The hope has been fulfilled.

Uptake of oxygen is reduced by synthetic detergents, though the effect diminishes as the concentration of sewage rises. Cetyl alcohol, which is being added to reservoirs in certain parts of the world to see whether it will reduce evaporation, also depresses the rate of oxygen uptake. Substances added to prevent foaming in activated sludge plants do not.

Work on oxygen has been the main preoccupation at the laboratory, experience having shown that the best policy is to keep the field of effort narrow, but much else has been accomplished as well. The toxicity of various substances to fish has been investigated. That of synthetic detergents is reduced by the activated sludge process. Ammonia occurs frequently in polluted waters and, in those charged with sewage, may be the main killing agent beyond the zone where lack of oxygen is acute. Concentrations of 10–15 parts per million N ammonia affect fish survival considerably. It occurs, too, in effluents resulting from the washing of coke oven gas together with phenol, which is less toxic. The effect of the two substances is complementary, and the toxicity can be calculated when the proportion of the two is known.

When the new Laboratory was being planned, a site to which large amounts of domestic sewage could be supplied was chosen. Research making use of this facility is following two lines: the elucidation of the fundamental nature of certain processes that are still largely empirical in operation; and methods of treating different kinds of effluent. To the first category belongs a study of the structure of the biological film of a percolating filter and of factors which modify it; the reviewer wonders whether much progress will be made with this until more precise names than 'zoogloeal bacteria', 'nematodes' and 'protozoa' can be given to the organisms involved. What exactly happens during the activated sludge process is another thing that the staff intend to find out.

T. T. Macan

TASTE AND SMELL

THE senses of taste and smell from the physiological and psychological points of view formed the subject of one of the periodical discussion meetings at the Society for Visiting Scientists, London, on May 21. The degree of attention paid during the general discussion to psychological rather than to physiological factors might be held to indicate that, in certain circumstances at least, the scientist was just as interested in his own subjective psychological processes as in the pursuit of objective data. Dr. H. Kalmus (University College, London), one of the three opening speakers, began by sketching-in some of the anatomical and physiological background of the receptor organs for taste and smell and then went on to describe some of his own work and that of his associates in this field. Following up the earlier discovery that phenylthiourea tastes bitter to some people but is apparently tasteless to others, and that this varying power of perception was hereditary, Harris and Kalmus had shown that this simple genetical difference applies, in fact, to a large group of substances containing the CNS group but to no others. In a second line of work, using a series of feeding experiments with two hives of bees and two different food sources, in which use was made of the dancing motions of bees as a method of information transference, Kalmus, together with C. R. Ribbands, had succeeded in confirming von Frisch's discovery that the bees were able to distinguish the taste of bees from their own hive from that of those from the other hive. In this case, however, the power of distinction was not hereditary. Dr. Kalmus had also worked on the power of odour perception in dogs. He had demonstrated that a dog which had been given the scent of a man's hands could successfully recover a handkerchief scented in the man's armpit from a number of other handkerchiefs scattered about the room, and could trace the man across a field in the open air from the scent left on a handkerchief when the trail was confused by a number of other men. In trials indoors with identical twins the wrong twin might be followed instead of the right one, though in the open air there was some indication that the right twin might be followed in preference. The most interesting point here seemed to be that the dog could recognize a man from his armpit odour (on the handkerchief), having previously been given only the hand odour, whereas to a human being there seemed to be more resemblance between two different armpit odours than between the hand and armpit odours of the same individual. This seemed to indicate a different and perhaps altogether higher power of integration in the dog; Mr. B. Babington Smith used the illuminating analogy of a musician who might recognize that two sounds apparently different to a non-musical ear were in fact merely octaves of the same note.

Mr. Babington Smith (Institute of Experimental Psychology, Oxford), the second speaker, described some work on non-expert consumer preference panels composed of undergraduates, in which he had been interested rather in the methodology and in the reactions of his subjects than in the actual results of the tests. The tests were confined to simple paired comparisons on red wine and chocolate, though Mr. Babington Smith did not stress the actual results beyond rather mischievously suggesting that there was some indication that the more intelligent people preferred plain to milk chocolate. The incidental

results were more illuminating. Though consistency was generally aimed at, an individual's reactions, it appeared, were seldom completely consistent and might be based on changing standards as the trial proceeded. The order in which the material was presented might be important, and there was also a problem in the actual quantity of the test material that should be provided. It was possible that the subject might learn about the technique of making comparisons as the test proceeded, and also that an initial preference might turn almost to nausea before the trial was over. Mr. Babington Smith distinguished between 'competitors' and 'co-operators' among his subjects; the former seemed anxious to find what they felt to be the 'right' answer, whereas the latter did more nearly what they were asked, which was to provide a straightforward description of their reactions. The first type might be useful on expert tasting panels, and the second, who might perhaps be regarded as having the instincts of a gourmet, would be useful in a consumer tasting panel.

Several speakers in the subsequent discussion were not happy about this classification. Mr. Babington Smith indicated that he did not intend a rigid classification into psychological types, his description only applying within the framework of the experiment; he also agreed that there might be a tendency for the less-experienced tasters to be anxious to find the 'right' answer, whereas the more experienced individual was more likely to be relaxed and confident in his appreciations.

The third main speaker, Mr. W. J. Gleeson (Reckitt and Colman, Ltd., Norwich), described a problem on market research for a food manufacturer. This was admittedly in the strict sense an unscientific business, but it was demonstrably possible for consumer surveys of this kind to convey information of which the manufacturer was not aware, and to indicate that the consumer had detected something that the manufacturer had not expected him to notice. The consumer in any event liked to be asked his opinion and would volunteer it even if he was not asked; and so they asked him. One of the principal difficulties in this type of work arose from the fact that the consumer would subsume all the factors affecting his preference, even colour, into the omnibus expression 'flavour'. Other difficulties arose from the necessity to compensate statistically so far as possible for the kind of error-inducing factors which had already been described by Mr. Babington Smith.

During the general discussion, some attention was given to the inevitability, or desirability, according to one's point of view, of using a combination of two or more of the senses in arriving at a subjective judgment of quality. In this connexion, Prof. H. D. Kay (National Institute for Research in Dairying, Shinfield) referred to cheese, Dr. H. J. Strausz (consultant chemist) to essential oils, and Mr. H. J. Bunker (consultant microbiologist)—who started with the story of the small girl who said she could hear the bacon smelling—to beer. Mr. Bunker's work, in contrast to most of the rest, was concerned with expert tasting in pursuit of the maintenance of a standard rather than with consumer preferences. In his field, the powerful assault of hops on the palate provided one of the major difficulties to extended tasting tests. Dr. G. Slot (physician) referred to the deliberate addition of emotional overtones to consumer preference, and instanced his hospital patients, who greatly preferred an expensive but widely advertised glucose drink to his own free prescription for the same material, as well as to those patients who reacted quite differently to red pills and blue pills even when both were aspirin. Mr. R. B. D. Stocker, as a dentist, picked up a reference made by Mr. Gleeson to fashions in taste, and said that in recent years the public taste had changed in a manner inimical to health. Mr. J. M. Harries (Ministry of Agriculture, Fisheries and Food) emphasized that one should not accept a stated preference as valid unless one had previously established the subject's ability to differentiate between the materials on trial, and Dr. Hugh Davson (University College, London) expressed the distaste of a physiologist for experiments in which the subject was asked to express a preference as opposed to those in which he was merely asked if he could tell the difference between two stimuli. Perhaps the last word lay with Dr. Kalmus, who thought that the whole subject would probably remain largely empirical and that it would be a long time before any sweeping, unifying theory emerged.

D. Neville-Jones

USE OF ISOTOPES IN AGRICULTURE

THE European Contact Group on the uses of isotopes and radiation in agricultural research has been established by the Food and Agriculture Organization of the United Nations to provide a medium for the exchange of information between European countries on present and planned programmes with the view of identifying applications likely to be of greatest significance for European agriculture. The object is to enable countries to pool their knowledge and experience for the common good and to make most effective use of the facilities available. The first meeting took place at Wageningen, in Holland, during December 10–14, and a report of the proceedings has recently been published*. It was attended by thirty-one representatives of sixteen European member governments and by observers from the United States and the U.S.S.R. and eight international organizations. Dr. S. L. Mansholt, Minister of Agriculture, Fisheries and Food in the Netherlands Government, announced that his Government had decided to establish an institute at Wageningen for the application of atomic energy in agriculture and as a centre of research, instruction and information. He expressed the hope that this would not remain a purely national institute, but would in due course develop into a European centre for the application of atomic energy in agriculture.

Discussions on the use of isotopes and radiation in agricultural research were organized under five subject headings. The topics concerned with the use of isotopes in soil science included the validity of the isotope technique, determination of active fractions of various soil ions by the isotope-dilution technique, use of labelled fertilizers, vertical migration of soil ions, exchange of ions between roots and medium, and evolution of organic matter in the soil. The delegations described how isotopes are being used in

* Food and Agriculture Organization of the United Nations. European Commission on Agriculture: Sub-Commission on Agricultural Research. Report of the First Meeting of the European Contact Group on the Uses of Isotopes and Radiation in Agricultural Research, held in Wageningen, Netherlands, 10–14 December, 1956. Pp. ii+39. (Rome: Food and Agriculture Organization of the United Nations, 1957.)

plant science to study such subjects as absorption of ions by leaves, uptake of minor elements, photosynthesis and sap movement in trees. The use of isotopes in animal science fell approximately into four categories, namely, intermediary metabolism, mineral metabolism, endocrinology and reproduction.

The fact that the genetic materials—the genes and chromosomes—are highly sensitive to ionizing radiations which induce hereditary changes or mutations has led to the exploration of the possibility of using this technique in improvement of crops. So far the method has been little used in animal breeding. The delegations indicated that useful mutations of cereals and other crops were being obtained.

The Group also discussed the reports which several countries presented on the use of radiation in the preservation and processing of food. This work is still in the developmental stage, and important problems need further investigation. At the moment, the destruction of insects in stored products, the suppression of sprouting in potatoes and root crops and the treatment of some fresh meats would appear to be the most promising applications of ionizing radiation to foods.

The nature of the financial provisions required for research programmes involving the use of isotopes and radiation was discussed, and the delegations made statements on the scope of training facilities for isotope research. Consideration was also given to the design and equipment of isotope laboratories for agricultural research. Attention was directed to the need for an international list of available labelled compounds. For the future, the Group agreed to continue its activity in organizing special meetings or symposia in particular aspects of soil science, plant science, plant breeding, animal science and use of radiation in food preservation.

E. C. Humphries

SCHOOL NATURAL HISTORY SOCIETIES

THE value of voluntary societies to the corporate life of the school and its fuller development is well brought out in three recent reports. The first, from Blundell's School, gives details of special Sunday evening lectures which are arranged by the Science Society and to which speakers of distinction have been invited over a period of many years. The hundredth of the meetings was celebrated during the year under review when the Society proudly welcomed back Mr. W. H. Dowdeswell, who had had much to do with the Society's foundation.

The role of the society in stimulating the pursuit of knowledge and truth for their own sakes is shown by the original investigations which form the bulk of the report. J. H. Becket describes observations made on catches in moth traps placed at ground-level and at a height of 80 ft. An account of experiments to compare soil temperatures under glass and polythene cloches with that of unprotected soil is given by W. L. Slater, while investigations of the flora of the Grand Western Canal are examined by C. Little. How woodlice maintain themselves in a moist environment has been investigated by A. J. S. Wearing; A. Lamb gives an account of the efficiency of the pollination mechanism in *Arum maculatum*. There is also a description of pollen and pollination in rhododendrons by A. Ridge.

Much of the report of the Rugby School Natural History Society is taken up with an account by J. A. D. Hope of his ornithological observations on the Isle of May for a short period in 1956. Hope was primarily concerned with records of the plumage and characteristics, voice and behaviour of the shag, the kittiwake and the fulmar; his essay is not unworthy of much more experienced ornithologists. Besides details of special lectures, the report contains information about the activities of the many sections comprising the Society. These include the museum, vivarium, library, zoological and entomological section; affiliated sections, the proceedings of which are described, include architecture, meteorology, photography, astronomy, railways, wireless, aeromodelling and philately. The Society has much to be proud of.

This is also true of the Oundle School Natural History Society, the report of which is mainly concerned with records of mammals, birds, fish, butterflies and moths, dragonflies, rotifers, crustaceans and plants observed in the neighbourhood of Oundle. An interesting account of laboratory animals shows that axolotls, African clawed toads, stick insects, salamanders, eyed lizards and geckoes, various British lizards and tropical fish were all under observation some time during 1956.

OXFORD BOTANIC GARDEN

THE Botanic Garden at Oxford, which is the oldest in Britain, was founded and endowed as a Physic Garden by the Earl of Danby in 1621. The Garden was intended for "the improvement of learning" with special regard for the study of 'simples' or drug plants. It was laid out on the site of the old Jews' burying ground opposite Magdalen College, from which the Garden is still leased by the University.

In 1642 the Garden was ready, and Danby, having failed to secure the services of the King's gardener, John Tradescant, appointed Jacob Bobart, an old Brunswick soldier, as 'Keeper'—indeed, as 'Hereditary Keeper'. During the difficult years that followed, Bobart began to collect garden plants, mainly for their interest in medicine, and in 1648 he published a catalogue of 600 native British plants and twice as many from abroad.

A professor of botany was appointed by Charles II in 1669 but the post was not endowed, and the care of the Garden and even the duties of teaching largely lay in the hands of Bobart and later of his son; the younger Bobart made some of the first experiments on sexual reproduction, using male and female plants of the indigenous campion. Many of the plants that he cultivated, especially West Indian ferns, are probably growing in the Garden to-day.

Fifteen years after the death of Bobart a chair of botany was finally endowed by William Sherard. The new professors followed the custom of the century rather than the example of Bobart: teaching ceased. The herbarium grew, but the plants were neglected. In these circumstances, it was by instinct rather than by instruction that Gilbert White, the naturalist, and Sir Joseph Banks, who later founded and stocked the gardens at Kew, visited the Physic Garden as undergraduates and gained a not too favourable impression of botany as a systematic study.

More than a hundred years passed and the Garden was then put in charge of an energetic and versatile man who had new ideas about many things, including plants and gardens; in 1834 Charles Daubeny became professor of botany. He changed the name to Botanic Garden. He rebuilt the glasshouses and he replanned the beds. He made new collections of plants in their economic, historical and geographical relations, and he raised trees from seed sent to him by collectors in America, India and China, trees which may still be seen in the garden. He wrote a Guide to the Garden which appeared in three editions, built an official residence for the professor next to the Danby Gate, and he set up a fountain and two aquaria. One of Daubeny's activities reached out to a larger and later world. On the land adjoining the river, he laid out experimental plots designed to show the value of mineral fertilizers. Their effect was to inspire one of his pupils, John Lawes, to found what is now the Rothamsted Experimental Station. Daubeny gave the place a new name, and he also gave it a new purpose.

The past hundred years have seen another kind of transformation in the character of the Garden. It has been during this time that, by breeding wild plants and selecting their progeny, our modern garden flowers have been created. The wild parents were largely the 7,000 exotic species brought into our botanic gardens during the reign of George III, or more precisely, during the life of Sir Joseph Banks. In one year, 1789, there arrived in the Port of London *Rosa chinensis* and *Chrysanthemum indicum*, the parents of all our modern roses and chrysanthemums. The new plants are represented by these and by all the asters and dahlias, irises and narcissi of our outdoor gardens, the begonias, pelargoniums, fuchsias and orchids of our glasshouses. The result of this new experimental horticulture can be seen in any flower show. In the Botanic Garden the stages in its history, which are quickly lost and forgotten elsewhere, are carefully and fortunately preserved.

An account of the Garden as it exists to-day has been prepared by the keeper, Prof. C. D. Darlington, and the superintendent, G. W. Robinson*. It contains details of the more interesting plants, when they were planted, and where they came from. All botanists would be glad to possess it.

T. H. HAWKINS

* Oxford Botanic Garden. Pp. 48. (Oxford: Basil Blackwell, 1957.) 2*s.* 6*d.*

ADAPTIVE RADIATION OF TRAPDOOR SPIDERS

THE spiders of the tribe Aganippini show a striking sequence of adaptation to habitats ranging from moist forest situations to desert environments. These have been investigated in Western Australia by Barbara Main (*Austral. Mag.*, 12, No. 5; March 1957).

The aganippinid spiders show a sequence of adaptation, represented by three dominant levels corresponding with a change from a moist to a dry environment. Associated with the change in habitat the spiders exhibit two main lines of adaptation. The first is associated with the reduction of water loss through the cuticle and the second is directed towards a more efficient feeding method when food is sparse. A thick abdominal cuticle, possessed by certain species, prevents loss of moisture from the body. *Idiosoma nigrum*, for example, has a tough, spiny, sclerotized abdomen in contrast to the soft, hairy abdomen of *Aganippe latior*.

Spiders which live in habitats having an abundant food-supply, such as the moist situations of litter formed from the wide flat leaves of such trees as eucalypts and banksias and which have the burrow opening among the litter, seize their prey from within reach of the burrow entrance but without emerging. Similarly, spiders occupying creek banks and claypans seize prey within reach of the burrow. Spiders in dry environments, however, such as the dry habitats around the bases of casuarinas and acacias, have a different technique of prey capture. These animals collect twigs and attach them singly, with silk, in radial arrangement, to the rim of the burrow. The twigs are then used as 'feeling-lines' for detection of prey. Spiders have been observed sitting in the burrow with the tips of the legs on the rim-ends of the twigs. Movements of insects on the twigs stimulate the spiders to run out of the burrow along the twigs in pursuit; in this way the spider greatly increases the area from which it can obtain prey.

Associated with the different methods of feeding, which varies in the distinct habitats, there are certain types of structure which represent three adaptive levels. The 'moist-dwelling' spiders have the head raised and sloping in such a way that the small, widespread eyes are directed only to the front. The poor eyesight of these animals is associated with the fact that in the litter they would be unable to see prey at any distance. Such animals also have short stout legs, adapted for supporting the thickset body within the burrow.

Spiders inhabiting bare-ground situations have moderately enlarged eyes, which is associated with seeing their prey in the open. The legs of these spiders are slightly longer and thinner than 'moist-dwelling' spiders; this is advantageous for quick movement partly outside the burrow.

'Twig-lining' animals have a flattened carapace enabling the eyes, which are greatly enlarged, to see in all directions. This is of great advantage when pursuing prey for some distance from the burrow. The legs are long and slender, adapted for running quickly on the flat surface outside the burrow.

Not only are the behaviour and body structure of the animals modified in adaptation to the different habitats, but they also construct different and characteristic types of doors to the burrows. Dwellers in moist habitats have thin, fragile doors made of silk-bound litter fragments. Those in open situations have soil doors; if in creek banks, the doors are thin and flaplike, whereas in claypans doors are thick and cork-like. Such a cork-like plug prevents the burrow being flooded when the bare ground is inundated after rain. Finally, 'twig-lining' spiders, which run out of their burrows to catch prey, construct thin, wafer-like doors of litter fragments that are very light in weight and stand open unsupported when flung up as the animal pursues its prey.

It is interesting that the various species, representing different adaptive levels, have apparently been derived from a common ancestor by its expansion into several types of habitat, where genetic recombination and natural selection have operated to produce forms which are modified, behaviourally and structurally.

VISUAL PIGMENT OF A DECAPOD CRUSTACEAN: THE LOBSTER

By Prof. GEORGE WALD and Dr. RUTH HUBBARD

Biological Laboratories, Harvard University, Cambridge, Mass.

THREE animal phyla have developed well-constructed, image-forming eyes: vertebrates, molluscs, and arthropods. Among the molluscs, the visual system of the squid has been examined extensively[1]; and recently Kampa has described a photosensitive pigment ('euphausiopsin') from the eyes of certain euphausiid crustaceans[2]. The present communication describes the photosensitive pigment from the eye of a decapod crustacean, the lobster (*Homarus americanus*).

Nine-tenths of all the vitamin A that a lobster possesses may be concentrated in its eyes[3]; and virtually all this is in the form of the hindered *cis* isomer, neo-*b* (11-*cis*), the precursor in vertebrate eyes of rhodopsin and iodopsin[4]. In addition to vitamin A, the lobster eye contains large quantities of astaxanthin, and small amounts of other coloured carotenoids[4].

The animals used in this investigation had not been dark adapted. The eye stalks were removed under room light, and stored up to four months at −15° C. Preparatory to extraction, the eye was cut away from the body of the eye stalk with a razor blade. This and all subsequent operations were performed in dim red light.

In preliminary attempts to extract visual pigment, the whole eye tissue was used. Though this was extracted repeatedly with petroleum ether and aqueous buffers to remove light-stable pigments, the photosensitive pigment when finally extracted with digitonin was accompanied by so much protein-bound astaxanthin as to interfere seriously with its measurement.

The electron microscopy of insect eyes has shown that the rhabdomeres of arthropod ommatidia possess a highly regular microstructure, reminiscent of the outer segments of vertebrate rods and cones[5]. Like the latter, arthropod rhabdomeres probably contain the visual pigments; and their similarity in microstructure implies an essential similarity in chemical composition. In any event, this notion encouraged the attempt to isolate lobster rhabdomeres by using methods which had already proved successful in isolating the outer segments of vertebrate rods and cones[6].

Freshly excised eyes were thoroughly ground with mortar and pestle in small portions of 45 per cent sucrose in *M*/15 phosphate buffer, *p*H 6·5, to a final volume of 20 ml. The tissue suspension, in a centrifuge tube, was layered over with *M*/15 phosphate buffer, and spun in the 'Spinco Preparative' ultracentrifuge at 30,000 rev./min. for 15 min. A fine layer of tissue fragments, composed in part of rhabdomeres, floated in the interface between the sugar and buffer solutions. The remaining eye tissues were sedimented. The supernatant was stirred up to disperse the floating tissue, and poured off. The sediment was ground again in 45 per cent sucrose, centrifuged, and the interfacial tissue treated as before. This procedure was repeated twice, making a total of four such flotations. The combined rhabdomere suspensions, having been diluted further with buffer, were sedimented in the centrifuge. The supernatant, bright red-orange in colour from its content of protein-bound astaxanthin, was discarded.

The rhabdomere tissue was re-suspended in *M*/15 phosphate buffer, *p*H 6·5, and centrifuged for 30 min. at 12,000 rev./min. The supernatant, now only faint red-orange in colour, was discarded. The sediment was lyophilized, and the dry residue extracted four times by stirring with petroleum ether. The first such extract was bright orange in colour, the last colourless. The sediment was dried under suction, extracted in the cold with *M*/15 phosphate buffer, *p*H 6·5, and centrifuged. The faintly yellow supernatant was discarded. The sediment was resuspended in distilled water and re-centrifuged. The supernatant, now entirely colourless, was discarded. The sediment was stirred into 1 ml. of 2 per cent unbuffered digitonin and allowed to stand over night. The extract was cleared by centrifuging at 30,000 rev./min. for 15 min.

The absorption spectrum of a portion of this extract, brought to *p*H 9·3 with sodium carbonate, is shown in Fig. 1, curve 1. It displays a maximum near 500 mμ, and absorption which rises into the ultraviolet. The spectrum was recorded to 310 mμ, though this portion is not shown in Fig. 1. This solution was exposed for 1 min. to the light of a microscope lamp passing through an orange Corning 3482 filter. The spectrum, recorded 2·5 min. later, showed that a photoproduct had formed, lying at shorter wave-lengths than the original pigment, and possessing a higher absorption maximum (curve 2). The solution was now left in the dark, and its absorption spectrum recorded periodically. The absorption fell regularly in the neighbourhood of 490 mμ, and rose in the neighbourhood of 370 mμ, marking the formation of retinene.

When the dark reaction had been completed (curve 11), a small inflexion remained near 480 mμ, caused by the presence of a trace of astaxanthin. The flotation procedure had eliminated nearly all this contaminant.

To the solution of curve 11, hydroxylamine was added to a final concentration of 0·1 *M*. Hydroxylamine takes retinene away from its fortuitous combinations with other amino-compounds, to form the single product, retinene oxime. The spectrum of this substance does not change with *p*H, and possesses virtually no absorption at wave-lengths longer than 450 mμ[7]. For these reasons, difference spectra computed by subtracting the spectrum of the hydroxylamine-treated product from curves 1 and 2 of Fig. 1 also are independent of *p*H, and above 450 mμ have the force of true absorption spectra.

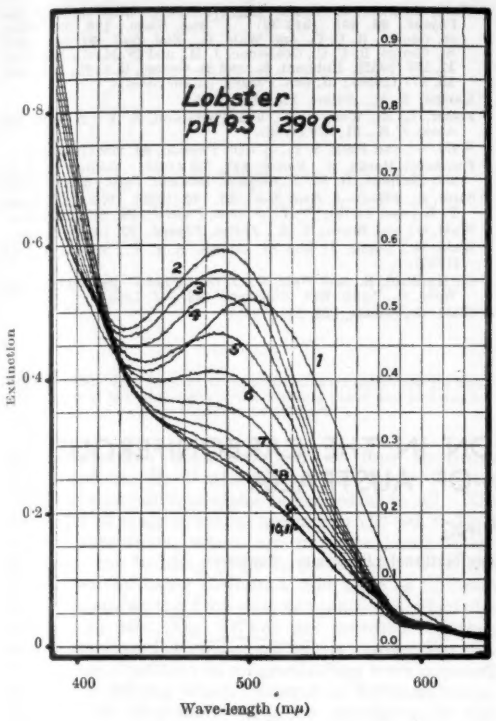

Fig. 1. Absorption spectra, recorded photoelectrically, of a preparation of lobster rhodopsin and the course of its bleaching (*p*H 9·3, 29° C.). Curve 1 shows the spectrum of the original preparation, measured in the dark. The solution was irradiated for 1 min. with bright orange light, and its absorption spectrum recorded at once (curve 2; 2·5 min.) and periodically thereafter in darkness: (3) at 8 min.; (4) at 16·5; (5) 31·5; (6) 50·5; (7) 84·5; (8) 135; (9) 190; (10) 232; and (11) at 254 min., from the start of the irradiation. The far ultra-violet portions of these spectra are omitted; they were recorded to 310 mμ.

Such difference spectra are shown in Fig. 2. The photosensitive pigment possesses an absorption maximum ($\lambda_{max.}$) at about 515 mμ. For the present we shall call this pigment 'lobster rhodopsin'.

On irradiation, the extinction rises and $\lambda_{max.}$ is displaced to about 490 mμ. The photoproduct resembles what we have called metarhodopsin, an orange intermediate in the bleaching of vertebrate rhodopsin[9]. Like the lobster photoproduct, the absorption of vertebrate metarhodopsin lies at shorter wave-lengths than rhodopsin, and in certain cases it possesses also a higher extinction. Lobster metarhodopsin, however, is very much more stable than vertebrate metarhodopsin. To obtain a record of vertebrate metarhodopsin comparable with Fig. 1 or 2 we have had to work at about − 20° C.; whereas the lobster measurements were made at about 29° C.

In the dark, lobster metarhodopsin, like the vertebrate photoproduct, goes over to a mixture of retinene$_1$ and opsin. The rise of absorption on bleaching, shown in Fig. 1, is maximal at about 370 mμ, the $\lambda_{max.}$ of retinene$_1$ in such preparations at *p*H 9·3. Retinene$_1$ oxime in digitonin solution has $\lambda_{max.}$ 362 mμ, corresponding with the minimum in the difference spectrum shown in Fig. 2. The identity of the retinene was further established by extracting it from a solution of bleached lobster rhodopsin, and mixing with antimony chloride. A dominant absorption band appeared at about 650 mμ, moving within 30 sec. to 664 mμ; this behaviour is characteristic of retinene$_1$. A small amount of vitamin A_1 also was present. The lobster retina contains such large amounts of vitamin A that the trace found in these extracts probably represents only a contaminant.

The conversion of lobster metarhodopsin to retinene and opsin follows the course of a first-order reaction. At *p*H 9·3 and 29° C. (Fig. 1), the time for half-completion of this reaction is 43 min., and the first-order constant, k, is 0·016 min.$^{-1}$. This reaction proceeds in the same manner also at *p*H 6·5.

In such extracts as these, the mixture of retinene$_1$ and opsin is the final product of bleaching. If to this final solution one adds a granule of potassium borohydride, the retinene$_1$ is promptly reduced to vitamin A_1. Whether this reaction also occurs enzymatically in the lobster eye remains to be determined. The large amounts of neo-*b* vitamin A normally present in the eye imply that this substance is the precursor of lobster rhodopsin, and make it probable that, as in vertebrates, the rhodopsin takes part in a retinal cycle[9] which includes vitamin A.

We have referred to the lobster visual pigment as a rhodopsin, following a usage suggested some years ago, according to which all vertebrate rod pigments which have retinene$_1$ as prosthetic group are called rhodopsins, and are designated further by the name of the animal of origin[10]. Since the pigments of the lobster and squid are so similar to vertebrate rhodopsins in composition and properties, we call them also 'rhodopsins'. We suggest that this nomen-

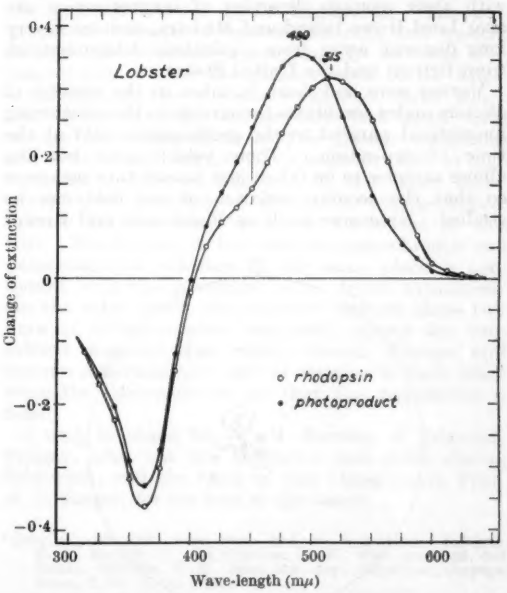

Fig. 2. Difference spectra of lobster rhodopsin and of an early product of its irradiation (photoproduct). These were obtained by subtracting from curves 1 and 2 of Fig. 1 the absorption spectrum of the final product of bleaching (curve 11), after treatment with hydroxylamine to convert retinene to retinene oxime. Since retinene oxime has virtually no absorption above 450 mμ, the difference spectra are equivalent to true absorption spectra above this wave-length, marked in the figure with a vertical line. Lobster rhodopsin has λ(max.) 515 mμ, the photoproduct λ(max.) 490 mμ; and the minimum at the left corresponds to the absorption maximum of retinene oxime at 362 mμ

clature be retained until a wider survey of vertebrate and invertebrate pigments has been accomplished. It may then appear that further designations are useful, based upon whatever general distinctions have emerged. At present, however, the attachment of specific designations to each invertebrate pigment to be extracted ('cephalopsin', 'euphausiopsin') can only lead to confusion. It is easier to make new nomenclature than to get rid of old. The less nomenclature we make now, the less we shall have to regret later.

This investigation was supported in part by funds from the Rockefeller Foundation and the Office of Naval Research. We are indebted to Mr. Stanley Burg for gifts of lobster eyes.

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DIRECTIONS OF MAGNETIZATION IN THE CARBONIFEROUS GLACIAL VARVES OF AUSTRALIA

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THE varved sediments in the Upper Kuttung Series of New South Wales have some interesting magnetic characteristics. Their average magnetic inclination is 84°, indicating that they were deposited in a high latitude and is therefore in agreement with their glacial origin. The pole positions consistent with their average direction of magnetization are near Lord Howe Island and Madeira, and are a very long distance away from equivalent determinations from Britain and the United States.

Varves were laid down in lakes in the vicinity of glaciers under conditions favourable to their becoming magnetized parallel to the geomagnetic field at the time of deposition. Their year-by-year banding allows samples to be taken in a known time sequence so that the secular variation of the field can be studied. Extensive work on Pleistocene and Recent varves[1] has provided information about the average direction and variation of the geomagnetic field during a small portion of these periods. Australia is fortunate in having glacial varves of very much greater age, notably in the Proterozoic and Carboniferous. Work has begun with an investigation of the stability and a determination of the average direction of the magnetization of varves in the Kuttung Series in the Hunter Valley.

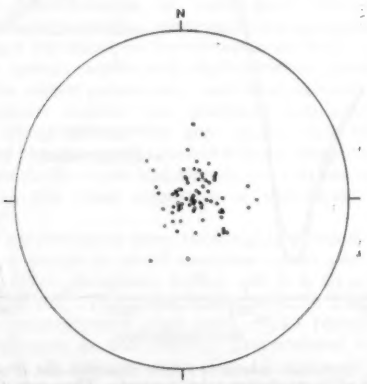

Fig. 1. Directions of magnetization in varve specimens. The directions are plotted on the lower hemisphere of a stereographic polar projection. This projection is also used in the other figures. Dots signify north-seeking poles (sites *A*, *B* and *D*) and circles south-seeking poles (site *C*). Correction is made for geological tilt, so that the plane of the projection is the bedding plane, which is assumed to have been horizontal at the time of deposition

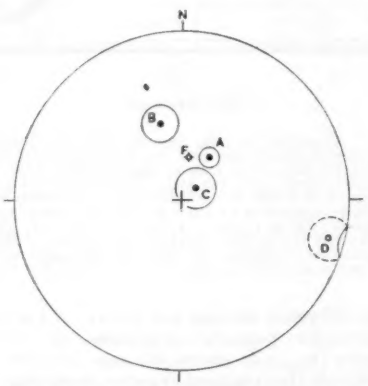

Fig. 2. Mean directions at four localities uncorrected for tilt of the beds.
The plane of the projection is the present horizontal, so that the directions are as they are in the field. Plotting is on both upper (circles) and lower (dots) hemispheres. *F* is the direction of the present Earth's field

The Upper Kuttung Series is of Upper Carboniferous age and consists of volcanics, glacial and peri-glacial deposits[2]. Results from the volcanics are being reported elsewhere[2]. The varves are for the most part grey or buff in colour, their intensities of magnetization are low ($3–10 \times 10^{-6}$ e.m.u., c.g.s. per c.c.) and their directions unstable; the varves at the type locality of Seaham exhibit such characteristics. But occasionally thin bands of pink or red colour occur,

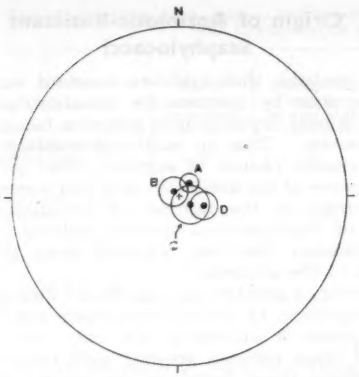

Fig. 3. Mean directions at four localities after correction for tilt. The plane of the projection is the bedding plane and plotting is on the lower hemisphere

and these have been sampled at four localities (designated *A*, *B*, *C* and *D*) in the lower Hunter Valley, seventy-five samples being taken in all. The intensities of magnetization are higher ($10–50 \times 10^{-6}$) and the directions, which are more or less perpendicular to the bedding (Fig. 1), are stable. This has been shown by using Graham's fold test[4] as follows: the directions at the four sites are scattered when the beds are *in situ* (Fig. 2) but are grouped together after correction for geological tilt is made (Fig. 3). Thus, these directions of magnetization were imposed prior to the folding which occurred in Permian times, and may be identified with the directions of the Earth's magnetic field in this region during the Upper Carboniferous. At site *C* the north-seeking directions of magnetization are directed towards the upper bedding surface, whereas at the other three sites they point downwards in the sequence. According to current terminology these are designated normal and reversed, respectively.

It may be supposed that, when the secular variation is averaged out, the geomagnetic field approximates to a geocentric dipole. Assuming this average has been achieved, the poles of this dipole axis may be calculated and are given in Table 1 and plotted in Fig. 4. These poles are between 80° and 90° distant

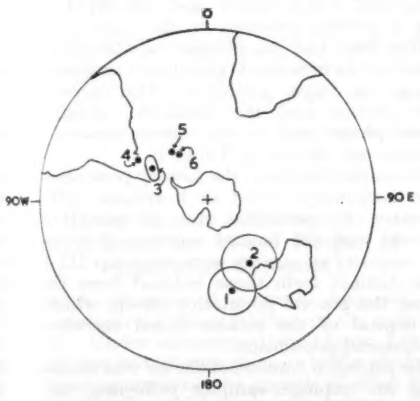

Fig. 4. Pole positions in Carboniferous times
The poles are numbered as follows: 1 and 2, Kuttung varves and lavas of Australia; 3 and 4, Naco sandstones (Pennsylvanian) and Barnett shales (Mississippian) of the United States; 5 and 6, Lower Carboniferous sediments and lavas of Britain

Table 1. Mean direction of magnetization is specified by its declination *D* measured east of geographical north, and inclination *I* positive downwards. α is the Fisher (ref. 8) angle of confidence at $P = 0{\cdot}95$. Because of reversals, the sign of this direction is uncertain. The pole errors δp and δm in the direction of, and perpendicular to, the co-latitude are at $P = 0{\cdot}95$

Mean direction of magnetization			Sampling area		Pole positions			
D	*I*	α	Lat.	Long.	Lat.	Long.	δp	δm
90°	+ 84°	6	33° S.	151° E.	165° E.	32° S.	12	12
270°	− 84°				15° W.	32° N.		

from determinations from the Mississippian[5] and Pennsylvanian[6] of the United States, and from the Lower Carboniferous of Britain[7]. Although comparatively small statistical differences may separate the Carboniferous poles of Britain and the United States, it seems very probable that for these regions at this time the pole lay in what is nowadays the South Atlantic with the anti-pole in eastern Asia, and the geomagnetic field over these regions was substantially dipolar. The complete disagreement of the Kuttung poles suggests either that Australia has moved relative to Britain and the United States, or that the geomagnetic field, although approximately dipolar over a large part of the northern hemisphere, was not so in the southern hemisphere.

The preceding argument does not assume any correlation of the magnetic and rotational axes of the Earth, but in order to make comparisons between the palæoclimatic and palæomagnetic data, let it be supposed that when averaged over several thousands of years the geocentric dipole has always been directed along the axis of spin. This may be referred to as the geocentric axial dipole hypothesis. The geographical latitudes of eastern Australia and western Europe now become approximately 80° and 70°, respectively. Since the pioneer work of Sir Edgeworth David, the climatic conditions under which the Upper Kuttung Series were laid down have always been regarded as cold or glacial—conditions which are most likely to have been attained in high latitudes. Western Europe, on the other hand, provides no evidence of glaciation, and geological opinion favours warm and wet conditions at this time. The agreement between the palæoclimatic and palæomagnetic evidence at the same place is consistent with the geocentric axial dipole hypothesis. On the other hand, the contrast between these two lines of evidence when antipodal regions are considered suggests that either western Europe and eastern Australia have moved relative to each other since the Carboniferous, or that this hypothesis is false.

I wish to thank Dr. W. R. Browne, of Edgecliff, Sydney, who was my instructor and guide during field-work, and the head of this Department, Prof. J. C. Jaeger, for his help in discussion.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Nitrogen Fixation by a Species of *Pullularia*

During the past few years an increasing number of organisms, other than *Azotobacter* and *Clostridium* species, have been found to fix small quantities of atmospheric nitrogen. *Chromatium* sp.[1], *Aerobacter aerogenes*[2], *Methanobacterium omelianskii*[3], *Pseudomonas*-like soil bacteria[4] and soil yeasts (*Saccharomyces* and *Rhodotorula* species[5]) have all been reported in the past three years as fixing atmospheric nitrogen. Nitrogen fixation by various lichens has also been described[6].

In the course of investigations by one of us (M.E.B.) concerning the stimulation of nitrogen-fixing organisms in the rhizosphere of clover plants grown in a clay–loam soil (*p*H 6·8) a black yeast-like organism regularly appeared on nitrogen-deficient agar plates. It has been identified as a species of *Pullularia*. On transfer to 10-ml. quantities of glucose–phosphate liquid medium containing no source of combined nitrogen the *Pullularia* grew well. After 14 days, nitrogen content assessments were made on replicate cultures by the micro-Kjeldahl method; compared with controls, gains of nitrogen of 0·20–0·26 mgm. per culture were found, corresponding to a fixation rate of 4–5 mgm. of atmospheric nitrogen per gm. of glucose supplied.

An estimation of the numbers of *Pullularia* in the clay–loam soil gave an approximate count of 8×10^3 cells per gm. of soil. The fungus was no more abundant in the rhizosphere of clover plants than in the surrounding soil.

Independently, Metcalfe has isolated what appears to be the same fungus from chalk soil, heath soil and a woodland mull soil and also from the thallus of the lichen *Cladonia uncialis*. These isolates grew readily in nitrogen-deficient washed agar media and in liquid media without added nitrogen compounds.

Grown on nitrogen-rich media, the fungus very rapidly loses its ability to fix atmospheric nitrogen. On nitrogen-deficient agar media, most of the growth is within the agar as rhizoid-like outgrowths from a small surface colony. Dark brown or black pigmentation occurs after a few days growth. On malt or yeast agar, pigmentation is usually slight.

We are indebted to Dr. Beryl L. Brady for identification of the organism as *Pullularia* sp.

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Origin of Antibiotic-Resistant Staphylococci

It is probable that antibiotic-resistant variants of bacteria arise by spontaneous mutation, and their further spread depends upon selective factors in the environment. Thus an antibiotic-resistant variant has a greater chance of survival when growing in the presence of the antibiotic, and this would explain the increase in the number of penicillin-resistant strains of *Staphylococcus pyogenes* isolated from hospital patients that has occurred since the introduction of the antibiotic[1].

However, a peculiar and significant finding is that the proportion of penicillin-resistant staphylococci in hospitals is increasing not only among those isolated from patients treated with penicillin, but also among those found in the noses of healthy carriers among the medical and nursing staff, most of whom have not been treated with the antibiotic. Thus, more than 90 per cent of the nasal carriers in a hospital may harbour penicillin-resistant *Staph. pyogenes*[2] and new personnel entering hospital with carrier strains which are penicillin-sensitive are, for the most part, rapidly colonized by the penicillin-resistant forms[3]. It has been suggested that these penicillin-resistant strains are acquired from the patients by contact and cross-infection, but it is unlikely that the penicillin-resistant strains are more suited to colonization of the healthy nose than the penicillin-sensitive strains, for, if this were so, one would expect their spread among the general non-hospital population. Our observations over the past few years show no evidence that there is a significant increase in the proportion of penicillin-resistant staphylococci among the general population.

A possible explanation is that the nurses and medical staff receive enough antibiotic on their hands and fingers and from the air to maintain a selective concentration in their noses which inhibits the penicillin-sensitive staphylococci. Confirmation of this possibility was sought by investigating the incidence of resistant strains in healthy carriers in an environment contaminated with antibiotic but which lacked treated patients as a source of resistant strains. Such an environment was a factory which handles and dispenses penicillin.

The staff of this factory, and a group of individuals from a general practice in the same geographical locality who had no contact whatsoever with the factory or its personnel, were first examined for nasal carriage of *Staph. pyogenes*. The carrier-rates for these groups and the antibiotic sensitivity and bacteriophage type of the carrier strains of *Staph. pyogenes* are shown in Table 1.

The carrier strains in the factory personnel resemble those commonly found in hospitals both in their resistance to penicillin (due to penicillinase production) and the limited number of types present. The majority of strains were of group III types and quite distinct from those isolated from the carriers among the general population group, which, in turn, are typical of the strains found elsewhere in the non-hospital population.

The penicillin content of the air was measured next, using an impinger-sampler collecting on to agar plates. The results are shown in the last column of Table 1. The concentration of penicillin present in the air of the penicillin filling-room and packing-room appears to be sufficient to depress the growth

Table 1. NASAL CARRIERS OF *Staph. pyogenes* INSIDE AND OUTSIDE THE PENICILLIN FACTORY. CHARACTERISTICS OF THE CARRIER STRAINS AND CONCENTRATION OF PENICILLIN IN THE AIR OF THE FACTORY

Group	No. of persons examined	Average No. of organisms on nose swab	Carriers of *Staph. pyogenes* (per cent)	Percentage carrier strains				Approximate recovery of penicillin per cu. ft. of air
				Penicillin-resistant	Phage group I	Phage group II	Phage group III	
Penicillin filling-room and packing-room	38	+	8	100	33	0	66	Filling-room 0·1–0·5 μgm. penicillin Packing-room 0·02–0·1 μgm.
General (no penicillin) packing-room	32	+++	27	100	36	0	60	Traces of penicillin. Amounts of other inhibitory material present
Administrative	28	+++	32	100	30	0	70	0
General population outside factory	36	+++	30	12	30	62	8	—

of all species in the nares of persons working in that environment, and the strains of staphylococci isolated were all penicillinase-producers. Much smaller amounts of the antibiotic were recovered from the air of other parts of the factory, which, though not sufficient to depress the growth of nasal flora, is sufficient to select and maintain penicillin-resistant *Staph. pyogenes*. Although no penicillin could be detected in the air of the administrative block, it is probable that traces of the antibiotic reach this site by air and dust, and on the clothing and fingers of the staff; thus it could be transferred to their nares and be effective in maintaining strains of penicillin-resistant staphylococci.

The evidence from these experiments confirms that penicillin in the environment is an important factor in selecting and maintaining penicillin-resistant strains of *Staph. pyogenes*. It is reasonable to compare the occurrence and distribution of these strains in this factory and a typical general hospital, and to suggest that antibiotic in the environment is the important factor in hospital which leads to widespread colonization of personnel with antibiotic-resistant strains of *Staph. pyogenes*. Investigations are in progress to try to demonstrate antibiotic in hospital air.

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Heleococcum aurantiacum: an Uncommon Weed Fungus of Mushroom Compost

MUSHROOM compost, if correctly prepared, is a selective medium for the mycelium of the cultivated mushroom. Under commercial conditions, however, various adverse factors may give rise to the production of a medium encouraging the growth of other fungus 'weeds', invasion by which may cause greater or lesser competition to the developing mushroom spawn. Some of these fungus invaders, such as *Oedocephalum* sp., *Papulaspora byssina* and *Coprinus* sp., are common; others, such as *Sporendonema purpurascens* and *Pseudobalsamia microspora*, occur sporadically; one or two are extremely rare, and of these latter the fungus *Heleococcum aurantiacum* has only occurred twice in samples examined in these laboratories.

In 1935, a compost sample was forwarded for examination. It was full of fine mycelial threads producing globular perithecia which contained numerous asci with eight ascopores in each. The curious thing was that the ascospores, as they ripened, became two-celled so that the ascocarps were obviously not those of the usually occurring Ascomycetes in compost. Specimens were forwarded to the Plant Pathology Laboratory to the late Dr. George Pethybridge for examination. In correspondence, he stated, "Your fungus is a puzzle and a very intriguing one. It has been shown to Mr. Ramsbottom of the British Museum, but he is unfamiliar with it". Later, Dr. Pethybridge wrote, "we have now succeeded in identifying your Ascomycete, at any rate as far as the genus is concerned. C. A. Jørgensen[1] . . . published (in English) an account of a new fungus which he called *Heleococcum aurantiacum* n.gen. n.spec. Mr. Ramsbottom came across it by accident not long ago and called our attention to it. . . . It is rather curious that although this paper was published twelve years ago, the new genus is not to be found mentioned in Saccardo or in Clements and Shear. In fact, it does not seem to have been gathered up into any published list so far as we can ascertain". Jørgensen's description is accompanied by excellent illustrations.

It was found in this laboratory that *H. aurantiacum* grew well on oatmeal agar and produced perithecia, and cultures were forwarded to the Centraalbureau voor Schimmelcultures.

Since 1935 there seems to be no further record of *Heleococcum aurantiacum*, and compost samples examined here have shown no signs of this fungus. This may be due, so far as mushroom compost is concerned, to improved methods of preparation and pasteurization, causing almost complete elimination of the more fragile weed fungi present. It was somewhat surprising, therefore, to find *Heleococcum aurantiacum* once more in compost samples in February of this year, after a lapse of twenty-two years.

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Relationship between Shoot Apex and Effect of Gibberellic Acid on Elongation of Pea Stems

Brian and Hemming[1] have recently shown that gibberellic acid is relatively inactive in inducing the elongation of internode segments of dwarf pea. They have found, however, that in the presence of indolylacetic acid, gibberellic acid induces a more marked increase in the extension of the internode segments.

It is of interest to note from previous accounts[2] that gibberellic acid induces much more marked increases in the elongation of stems of intact green plants than it does in stimulating the cellular extension of isolated plant parts (that is, wheat coleoptiles, pea internode sections, etc.). This is in striking contrast to the classical auxins, such as indolylacetic acid, which are much more easily detected in bioassays with isolated segments grown in the dark.

With these interesting and unexplained differences before us, we have looked into the effect of gibberellic acid on the elongation of stems of Alaska pea seedlings from which vital (from a physiological point of view) portions of the anatomy of the plant had been severed. The seedlings used in these experiments were grown in the dark until they were six days old. Ten uniform seedlings were then decapitated, for each replicate, by cutting through the first node with a sharp razor, or de-rooted, or left intact. The seedlings were then immersed in either aqueous solutions containing 10 p.p.m. gibberellic acid or in distilled water. One set of seedlings was placed under red fluorescent lights, while the other set was kept in total darkness. After two days, the total height of the seedlings was recorded. The results are reproduced in Table 1.

Table 1. Effect of Gibberellic Acid on Elongation of Etiolated Pea Seedlings with Different Tissues removed Prior to Treatment in Light and Dark

Tissues removed from seedlings	Total increments of growth (in cm.) for ten seedlings held in			
	Red light		Darkness	
	G.A. (10 p.p.m.)	Water	G.A. (10 p.p.m.)	Water
Shoot apices	2·4	2·7	4·6	2·0
Roots only	96·6	45·6	107·3	82·6
Roots and apices	5·3	2·1	3·7	2·9
None (Ck.)	93·2	50·4	106·0	87·3

Required for statistical significance: differences of 8·6 at 5 per cent level; differences of 9·7 at 1 per cent level.

Intact seedlings responded to gibberellic acid more markedly in red light than the dark, confirming the recent work of Lockhart[3]. Decapitated seedlings made little growth either in the presence of gibberellic acid or in its absence, regardless of whether they were grown in red light or in the dark. De-rooted seedlings with shoot apices responded to gibberellic acid much more markedly in red light than in the dark, acting similarly in this respect to intact seedlings. However, de-rooted seedlings, without shoot apices, which are, in effect, second internode segments, did not respond to gibberellic acid either in red light or in darkness, resembling decapitated seedlings with an intact root system.

The results of these experiments indicate that the shoot apex is necessary for maximum elongation of the second internode of Alaska peas and that gibberellic acid will not replace the stimulus for cellular extension that is probably derived from the apex.

In view of the report by Brian and Hemming[1] on a possible interdependence between indolylacetic acid and gibberellic acid, coupled with the results described here, there is some indication that there may be a close relationship between growth factors synthesized and translocated from the apex, and the exogenously applied gibberellic acid. One may speculate that this relationship is possibly a type of 'sparing action' by which exogenously applied gibberellic acid 'protects' against the inactivation of endogenous growth hormones, particularly where the inactivation mechanism is mediated by light. These and other questions will be discussed more fully in forthcoming publications in the Contributions from the Boyce Thompson Institute.

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Unisexual Flowers in the Ericales

The flowers of the Epacridaceae have been described as hermaphrodite[1,2] or hermaphrodite, rarely dioecious[3], but in the latter case no examples of dioecy are quoted. The following notes concerning species previously described as hermaphrodite indicate that unisexual flowers may be not uncommon in this family.

In November 1954 I noted that a lone plant of *Cyathodes colensoi* in the Christchurch Botanic Gardens flowered profusely but set no fruit. A year later a large population was examined at Lake Lyndon, Canterbury, and two types of plant were found which were obviously male and female. Five plants were labelled in the field, and only the two classified as female set fruit. Transplants from this population set no fruit in isolation, but did so with the appropriate hand pollination. The tiny stamens in the female may dehisce but contain no pollen (Fig. 1) and the flower illustrated by Cheeseman[4] is of this type. Female flowers are smaller than males. Although pollination has not been observed, the flower structure suggests that insects are the main agent, for the stigma is inside the petal tube, the opening of which is only $\frac{1}{2}$–$\frac{3}{4}$ mm. across and surrounded by hairs.

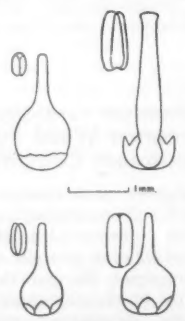

Fig. 1. Upper: *C. colensoi*, Lake Lyndon. Female, left; male, right. Lower: *C. acerosa*, Kaiteriteri. Female, left; non-fruiting hermaphrodite, right

In February 1956 at Kaiteriteri, Nelson, it was noted that some plants of *Cyathodes acerosa* were fruiting and others were not. Several plants of each type were marked, and the flowers were examined in the following October. The plants which had borne fruit were definitely female. The anthers were larger than those of female *C. colensoi*, but again were empty (Fig. 1). Cheeseman's illustration[4] is referable to this type. But those plants without fruit bore flowers which were hermaphrodite in structure, with good pollen and with ovules. The fruiting was rechecked in 1957 and the same result obtained as in the previous season. Similar types of flower were found near Springfield, Canterbury, and here again, in two seasons, marked female plants set fruit, but apparently hermaphrodite plants did not. In contrast, Mr. W. B. Brockie, of the Otari Gardens, Wellington, has a lone plant collected from Raetihi, North Island, which has hermaphrodite flowers, and which fruits abundantly each year. No macroscopic differences have been noted between flowers from this plant and the non-fruiting plants of the Kaiteriteri and Springfield populations. But the fruits from Otari are white whereas the others are red. The cause of the sterility of the apparently hermaphrodite plants will be investigated. Lack of either self- or cross-pollination may be ruled out. The anthers are on a level with the stigma and self-pollination is inevitable. Cross-pollination must also occur readily as shown by the fruiting females, and this will be easier than in *C. colensoi*, as the anthers and stigma are well exposed.

A population of *Leucopogon fasciculatus* near Springfield was also found to contain fruiting female plants and non-fruiting plants with apparently hermaphrodite flowers.

Hooker[5] noted that *C. colensoi* was closely allied to *C. tameiameiae* and to *Leucopogon suaveolens*. By the courtesy of Dr. W. B. Turrill, specimens of these at Kew were kindly examined for me by Dr. R. Melville. A specimen of *L. suaveolens* (A. E. Pratt, New Guinea, 1908) had normally dehisced anthers, young fruit and appeared hermaphrodite. Another sheet (Loher, 3784, Philippines) bore what were apparently male and female specimens. The males had large normally dehisced anthers and no developing fruit; the females had small, unopened anthers and young fruit. Specimens of *C. tameiameiae* were apparently either male with large normally dehisced anthers, or female with smaller anthers containing no pollen. Dr. Melville has pointed out to me that Skottsberg[6] had earlier suggested that dimorphous flowers occurred in this species (which he referred to *Styphelia*) and also in *C. douglasii*, but had considered gynodioecy probable.

The flowers of the Ericaceae have been described as hermaphrodite[1–3], but an exception is *Epigaea*, which is variously described as dioecious[7] or androdioecious or gynodioecious[1]. An early suggestion[8] that *Gaultheria antipoda* and *G. rupestris* of New Zealand are gynodioecious has been overlooked. Mr. H. Talbot has recently and independently noted that unisexual flowers occur in some New Zealand species of *Gaultheria* and *Pernettya* and these are being investigated to determine whether they are dioecious or gynodioecious. Thomson's record for *G. antipoda* has not been substantiated.

During this work a request was made to the University of Tasmania for further material of *Cyathodes*, and it was found that Dr. C. V. Rao, Colombo Plan Research Fellow, had independently found unisexual flowers in several genera of the Epacridaceae.

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Nature of the Bactericidal Agent in Sea Water

Earlier work by myself in co-operation with Miss R. E. Martin upon the toxicity of sea water towards *Escherichia coli* demonstrated the presence, in the coastal waters of New Zealand, of the bactericidal agent which has been observed by other workers and been the subject of a recent review by Greenberg[1]. We also found that this organism will survive and actively multiply in sea water containing a very small addition of lactose broth. Assuming that some constituent of the lactose broth was able to antagonize the toxic effect of the sea water, well-washed cultures of *E. coli* were suspended in mixtures of sea water and the individual constituents of lactose broth. The meat extract ('Lab lemco') was found to contain the protective agent. Yeast extract behaved similarly.

Following Miss Martin's departure overseas, I continued this lead by examining a wide range of pure substances likely to occur in meat or yeast extract, that is, amino-acids, vitamins, purine and pyrimidine bases, etc. Of the substances tested, cysteine gave protection to the bacteria at very low concentration, as shown in Table 1.

Table 1. Effect of Cysteine upon Survival Numbers of *E. coli* (*N.T.C.* 8796) in Filtered Sea Water

Cysteine added (μgm./litre)	No. of survivors after 18 hr. at 37° C.
0	1
3·5	5
35·0	180,000
350	180,000

That such an effect should be obtained from a sulphur-containing compound is interesting, as Harvey[2] states that cystine plus sodium sulphide or thiourea alone increased the growth of *Skeletonema costatum* in sea water media. Matudaira[3] obtained similar results by addition of sodium sulphide to sea water media.

These observations suggested that the toxic agent in sea water was in some way involved in sulphur metabolism or else interfered with the sulphydryl groups of essential enzymes. Some antibiotics are known to act by such a mechanism, but the universal distribution of the toxic agent throughout the oceans of the world did not suggest an organic substance of biological origin, but rather some substance of an inorganic character.

A consideration of the chemistry of sea water and a search of the literature revealed that Winkler[4] had

demonstrated that a considerable portion of the iodine naturally present in sea water was there as iodate, the remainder being iodide. In view of the known reactivity of halates and sulphydryl compounds at neutral *p*H values, this presence of iodate in sea water could explain the toxicity towards the coliform bacteria and their protection by cysteine.

The presence of iodate in the local coastal waters of Wellington, New Zealand, has been established by me. The method used was to acidify the sample, add potassium iodide solution, and then estimate the tri-iodide ion spectrophotometrically at 355 mμ. Sulphamic acid was used for acidification as it effectively eliminated nitrite interference. The amount found ranged from nil on polluted beaches to 0·034 p.p.m. iodate, which has an oxidizing power equal to 0·15 p.p.m. free iodine.

This postulation of iodate as the toxic substance in sea water is in agreement with (*a*) the universal distribution of the toxic agent throughout the oceans; (*b*) variable degree of destruction by autoclaving: the iodate reacting with organic matter, the degree of destruction is dependent upon the nature and quantity of organic matter present; (*c*) protection of the bacteria by cysteine.

Vacarro and his fellow workers claim to have destroyed the toxic agent by chlorination[5]. However, these workers removed the excess chlorine with thiosulphate, and it was possibly this latter substance reacting with iodate that gave increased survival of the test organism.

These investigations are proceeding.

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Separation and Identification of Aromatic Acids in Plant Tissues by Paper Chromatography

In the course of studies on the aromatic constituents of *Theobroma cacao* L., a method has been developed for the separation by one- and two-dimensional paper chromatography of the naturally occurring substituted cinnamic acids, which is also applicable to many other aromatic acids of plant tissue.

A separation of the common phenolic acids of plants has been reported by Bate-Smith[1], who employed a toluene solvent system and the Forestal solvent system. Both of these methods suffer, however, from the disadvantage that the substituted cinnamic acids, which are of very wide distribution[2], tend to lie very close together on the chromatogram, possessing R_F values within the range 0·78–0·86 in the Forestal solvent and 0·05–0·25 in the toluene solvent. Furthermore it has been observed that, in the plant material under investigation, several spots revealed by these uni-dimensional methods could be resolved by two-dimensional chromatography into two or more components. Similar difficulties are attendant upon the use of *m*-cresol/acetic acid/water and butanol/acetic acid/water for the separation of these compounds[3].

Table 1. R_F Values in Benzene / Acetic Acid / Water

	R_F values	Ultra-violet fluorescence	Colour with diazotized *p*-nitraniline
Substituted cinnamic acids:			
Chlorogenic acid	0	blue	brown
Caffeic acid	0·04	blue	red-brown
p-Coumaric acid	0·49	faint deep blue	orange
o-Coumaric acid	0·64	silver blue	yellow → red
Ferulic acid	0·90	blue	red
Dimethoxy cinnamic acid	0·99	blue	none
Miscellaneous hydroxy-aromatic acids:			
Ellagic acid	0	none	brown
Protocatechuic acid	0·07	none	brown → purple
Salicylic acid	0·98	deep blue	yellow
Gallic acid	0	none	brown

Of a large range of solvent combinations investigated in this laboratory, the best results were obtained with a benzene/acetic acid/water system (60 : 70 : 30), the substituted cinnamic acids showing a wide range of R_F values, and giving rise to spots of a small and well-defined character. This solvent system is, however, extremely sensitive to changes of temperature, and the water dissolved in the hydrocarbon phase may be expelled if such changes occur. It is therefore essential that the temperature be kept constant throughout the procedure. Care should accordingly be taken to ensure that the solvents and the vessel in which they are mixed are at the same temperature as the tank. After mixing, the solvent system is allowed to stand at this temperature for one hour, when the lower aqueous phase is removed. The hydrocarbon phase is allowed to remain in the separating funnel for a further 15 min., when any water expelled from the hydrocarbon phase is removed. At the end of this period, the hydrocarbon phase is transferred to the trough of a tank, which has been equilibrated with the aqueous phase for 24 hr. previously. The solvent system may be further stabilized by carrying out the procedure at a reduced temperature, the R_F values listed in Table 1 being obtained by ascending development of the chromatogram (Whatman No. 1 filter paper) in a constant-temperature room maintained at 15° C. In our current experiments the identity of the isolated compounds is confirmed by running them against reference compounds.

A development period of 3–4 hr., during which the solvent front advances about 25 cm., was found to give a good separation. In the case of complex mixtures of aromatic acids, it was found to be advantageous to submit the chromatogram to further development with a second solvent system. Although the previously reported solvent systems have not lent themselves to two-dimensional separations by reason of the somewhat diffuse character of the spots obtained in the primary development, the adoption of the benzene solvent as the primary solvent system, and the consequent improvement in the definition of the resulting spots, makes further development with a second solvent system wholly practicable. For this purpose acetic acid / hydrochloric acid / water (100 : 10 : 30) was found to be very satisfactory[1].

For the detection and identification of these compounds on the chromatogram, their properties of

fluorescing in ultra-violet light and of forming coloured derivatives on spraying with 1 per cent alcoholic ferric chloride or diazotized *p*-nitraniline[4] were utilized. The colours recorded in Table 1 were those produced immediately on spraying. In certain cases the colours first formed underwent further change on standing. These changes provided a further criterion for the identification of substances of similar R_F values.

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Ascorbic Acid Content of Baobab Fruit

The Hausa-speaking farmers and Fulani cattle owners who live in the savannah regions of Northern Nigeria make free use of the leaves and fruit of the baobab tree (*Adansonia digitata* Linn.). The leaves, either fresh or dried and pulverized, are used in the soup which is poured over the dish of porridge made from guineacorn (sorghum) or millet (pennisetum and eleusine) flour. During the season while the fruit of the tree is ripe, from February to April depending on the latitude, the pulp is removed from the fibres and seeds by kneading in cold water and then passing the emulsion through a sieve. The resulting white or whitish-yellow fluid (Hausa—*gubdi*) is used by the farmers to dilute the thick guineacorn dough (*fura*) to a thin gruel (*kunu*), which is the traditional morning or midday meal. The cattle-owning Fulani use the emulsion to adulterate milk. This milk and baobab fruit juice mixture is a popular drink with the Hausa farmer, and is available, if he has money to buy it, at a hot time of the year when new farms are being cleared, or hoeing of old farms is taking place, preparatory to sowing. The kernels of the seeds are used to make into a cake for flavouring soup.

Dalziel[1] says that the pulp of the baobab fruit "apparently contains free tartaric acid, potassium acid tartarate, with pectin, glucose and mucilaginous matter". Carr[2] has concluded, from the results of analyses using both the dichlorophenolindophenol and dinitrophenylhydrazine methods to estimate ascorbic acid, dehydroascorbic acid and diketogulonic acid, that the pulp contains large quantities of ascorbic acid; that this is present mainly in the reduced form, and that no appreciable amounts of substances which interfere with the dichlorophenolindophenol method of assay are present. The diets of the Hausa-speaking peoples throughout the rest of the year provide them with only small amounts of ascorbic acid, and it was considered to be of importance to determine whether Nigerian baobab fruit also contains good quantities of the vitamin.

The Hausa-speaking natives of Bunga-Ningi, in Bauchi province (11° N., 9·30° E.), were observed to consume quite large quantities of baobab fruit juice either in sour milk or in their morning gruel, the juice being stirred into the flour after it has been cooked. One of the farmers was asked to bring six fruits at the correct stage of ripeness for making the juice. The average composition of the fruits found is given in Table 1.

Table 1

	Mean weight (gm.)	Range (gm.)
Whole fruit	462	554–341
Capsule	203	249–156
Seeds and fibres (dry)	165	210–114
Ratio of pulp to weight of fruit	0·21	0·22–0·19

The dry pulp was scraped from the seeds, ground to a fine powder, and the moisture content estimated in a Carter–Simon oven, the average of three estimations on each of the six pulps being 20·8 per cent (range 18·1–23·1). The ascorbic acid content of the dry pulp was estimated by the 2 : 6-dichlorophenolindophenol method[3], the average of three estimations on each of the six samples being 373 mgm./100 gm., (range 302–445 mgm./100 gm.). These are higher figures than those given by Carr for Rhodesian baobab fruit.

It was found that an average-sized baobab fruit made about one litre of juice, using native methods of preparation, and that the ascorbic acid concentration in it was 75 mgm./100 gm. (range 54–106). It is apparent that a destruction of ascorbic acid takes place during the preparation of the juice.

The consumption of baobab fruit juice by the Hausa-speaking people of Bunga-Ningi was measured over a period of a week in late February 1957 and was found to vary from 130 gm. (adult males) to 27 gm. (children 4–6 years of age). Using the figures given above this would provide 98 mgm. and 20 mgm. of ascorbic acid. At other times of the year the intakes of ascorbic acid had been found to be 17 mgm. and 16 mgm. respectively. The length of the baobab fruit season is estimated by the population of Bunga to be about two months, and it is therefore an important source of ascorbic acid in the local diets.

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Nucleic Acid Derivatives in Soils

During investigations into the nature of soil organic phosphates, purine and pyrimidine bases have been identified in preparations from three representative mineral soils from north-eastern Scotland. They were found mainly in the humic acid fractions of the organic matter, that is, that portion of the organic matter which is precipitated when an alkaline soil extract is acidified, and were clearly not in the free state, but were released by perchloric acid hydrolysis. Afterwards they were separated from the bulk of the hydrolysate by adsorption on a cation exchange column (1*R*-120), from which they were eluted with 5 *N* hydrochloric acid and identified by paper partition chromatography with solvents butanol/ammonium hydroxide[1], and *iso*propanol/hydrochloric acid/water[2]. The bases so far identified are guanine, adenine, cytosine and thymine, which appear to be present in similar amounts, and smaller quantities of uracil. There is organic phosphate present in the humic acid fractions, equivalent to

about 10 per cent of the total soil organic phosphate, and the evidence suggests that part of this may be accounted for as deoxyribonucleic acid. The conditions under which the soils were extracted would cause considerable hydrolysis of ribonucleic acid to mononucleotides, which would not appear in humic acid precipitates, so that the small quantity of uracil relative to thymine in the precipitates cannot be taken as an indication of the relative amounts of ribonucleic acid and deoxyribonucleic acid in the original soils. The quantities found are in excess of the total amounts likely to be present in soil micro-organisms.

The presence in soils of substances having some of the properties of nucleic acids has been reported before[3], but more recent attempts[4] to confirm their presence proved inconclusive although there was some evidence that minute amounts of soil phosphates were in this form. Only ribonucleic acid or its derivatives were considered, however, and attention was confined mainly to the fulvic acid fractions of soils.

The presence of thymine in the hydrolysate of soils or soil products does not appear to have been reported previously, nor have the four bases of either type of nucleic acid been isolated from one product.

This investigation will be reported fully elsewhere.

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Isolation of Uranediol from the Urine of Pregnant Mares

The isolation of uranediol from the urine of pregnant mares has been described by Marker and his colleagues[1] and by Klyne[2]; isolation has also been effected by Bauld and Heard[3]. Since the reported isolations of uranediol have been few, and since uranediol appears to be the first D-homosteroid of natural origin to be isolated[4,5], we believe that it is of interest to record that we have isolated uranediol in small quantity from pregnant mares' urine collected throughout the second half of the term of pregnancy.

Urine was collected continuously in batches from a large number of mares during approximately the seventh, eighth, ninth and tenth months of pregnancy and each batch of fresh urine was processed by solvent extraction to a separate concentrate. A portion of each of the resulting concentrates, equivalent to 1 per cent of the total weight, was withdrawn and these samples pooled and hydrolysed, and a non-ketonic, non-phenolic fraction isolated. This non-ketonic, non-phenolic fraction was acetylated and on chromatography yielded an acetylated compound (approximately 300 mgm. per 100 gal. of urine processed) which melted sharply at 159–160°. The physical properties of this compound (melting point 159–160°, $[\alpha]_D^{25} - 28 \cdot 4°$ (chloroform)) and the analysis (C, 74·5, 74·4; H, 10·1, 9·9 per cent) agree with the values previously reported[1,2] for uranediol diacetate. The infra-red spectrum of our compound in the fingerprint region (in carbon disulphide) was measured by Dr. I. D. P. Wootton (Postgraduate Medical School, London) and was found to be identical with that of an authentic sample of uranediol diacetate supplied by Dr. W. Klyne.

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Production of Rat Serum Proteins in Irradiated Mice

In the course of a study on the protection of mice against a lethal dose of X-rays, it was found in this laboratory that the administration of homologous or heterologous (rat) bone marrow after the irradiation may result in a significant reduction of mortality. In the animals surviving after heterologous therapy the circulating erythrocytes were agglutinated by anti-rat serum; furthermore, the granulocytes showed an alkaline phosphatase reaction which is specific for rat white cells. These results proved that a transplantation of rat hæmatopoietic tissue had been achieved[1].

Since it is known that certain serum proteins are synthesized by cellular elements of the bone marrow, a serological typing of the serum proteins of these mice seemed of interest. Results from investigations by Makinodan[2] suggested a failure of the transplantation of rat plasmacytopoietic cells, since rat serum protein could not be detected in the circulation of lethally irradiated mice after treatment with rat bone marrow.

Precipitating anti-rat serum was produced by immunizing chickens with alum-precipitated rat serum. In testing the sera, the capillary precipitation reaction (ring reaction) was used. Sera were obtained which, after absorption with normal mouse serum, precipitated rat serum specifically with a titre of 1 : 80,000.

The sera of *CBA* mice were tested about 100 days after the irradiation and the treatment with rat (*WAG* strain) bone-marrow cells.

So far, 15 sera have been tested. A positive reaction was obtained in all cases indicating the presence of rat serum proteins in these mice. Two-fold serial dilutions of the antigen yielded titres ranging from 1 : 256 to 1 : 2,048 with the antiserum employed. These titres were not influenced by a previous absorption of the chicken anti-rat serum with intact and hæmolysed rat erythrocytes, indicating the specificity of the reaction for rat serum proteins. This result, together with the agglutination and alkaline phosphatase reactions, suggests that transplantation of rat hæmatopoietic tissue was complete. In preliminary experiments

applying micro-immuno-electrophoresis to these sera according to the method of Scheidegger[3], precipitation by anti-rat serum of a component travelling with the speed of normal rat gamma globulin was observed.

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Role of Organ-Specific Antigen during 4-Dimethylaminoazobenzene Carcinogenesis in the Rat Liver

In recent years, attention has been focused upon the immunological concept of the etiology of carcinogenesis. Burnet[1] has developed the thesis that the control of cell multiplication may in part be mediated by 'self-marker' antigens present in all expendable cells, and he has pointed to the work of Weiler[2] as strong support for Green's[3] immunological hypothesis of carcinogenesis. By use of the fluorescent-antibody technique of Coons and Kaplan[4], Weiler provided evidence to support his earlier observations[5] that the organ-specific antigen is absent from tumour cells. While frank tumour cells failed to fluoresce in the presence of the organ-specific fluorescent antiserum, the failure of islands of morphologically normal but perhaps pre-malignant parenchymal cells to fluoresce is of greater etiological significance.

As the implications of Weiler's work, particularly the demonstration of the loss of organ specificity in pre-malignant cells, bear directly upon the immunological concept of cancer it was considered necessary to confirm his observations. The results of our studies upon the role of the organ-specific antigen during 4-dimethylaminoazobenzene carcinogenesis in the rat liver are presented in this communication.

The methods described by Weiler[2] for the preparation of rat liver mitochondria and microsomes and immunization of the rabbits for the production of anti-mitochondrial and anti-microsomal sera have been followed. However, the rabbit anti-rat liver mitochondrial and microsomal sera were neither organ-specific nor species-specific and generally the sera gave as high a titre by the complement-fixation reaction with rat kidney particulate antigens (mitochondria and microsomes) as with the homologous rat liver antigens. End-point fixation (50 per cent hæmolysis) was observed with dilutions of the rabbit anti-rat liver sera to 1/640 in the presence of the liver antigens, while similar reactions were recorded with the kidney antigens with dilutions of the sera to 1/640 or 1/1,280. Comparable titres were obtained when the antisera were set up in the fixation reaction with mouse liver and human liver antigens. Rabbit antisera have also been prepared to rat kidney microsomes and mitochondria and again these sera exhibited neither organ nor species specificity in complement-fixation tests.

We have observed that the particulate rat liver antigens frequently agglutinated the indicator system (hæmolysin-sensitized sheep's red blood cells) and this phenomenon may account for the somewhat lower titres of the anti-liver sera against the homologous liver antigens when compared with the titres obtained in the presence of the heterologous kidney particulates. The results of the serological studies are thus in accord with the observations described by Macfarlane and Datta[6].

Following absorption of the anti-rat liver mitochondrial and microsomal sera with rat kidney particles, parallel drop in the serum complement-fixation titre was observed in the presence of both the liver and the kidney particulate antigens, and the antisera showed titres of 1/40 and 1/80 after the sixth absorption. All absorptions were carried out at 37° C. for 1 hr. and overnight at 3° C., as described by Weiler[2]. Thus absorption of the antisera with the heterologous antigen did not yield organ-specific sera.

Although a liver-specific antiserum has not been produced we have observed differential staining in sections of liver obtained from rats fed the carcinogen 4-dimethylaminoazobenzene. Non-staining areas of parenchymal cells, similar to the areas described by Weiler[2], were evident when the liver sections were treated with fluorescein-conjugated rabbit sera, but the difference was seen equally well with conjugation from normal rabbit serum as with the immune serum. The globulin fractions which were used in the conjugation of the normal rabbit sera did not fix complement in the presence of rat liver and rat kidney particulate antigens. Exhaustive extraction of the fluorescent sera with the rat kidney particles, which Weiler found to remove free fluorescein derivatives, also non-specifically absorbed much of the fluorescein-conjugated protein and greatly reduced the fluorescence of the stain. In later experiments, free fluorescein derivatives were removed from the conjugated sera by dialysis.

In addition to the non-staining areas of frank hepatoma and cholangioma, non-staining islands were seen in most sections of livers of rats fed 4-dimethylaminoazobenzene. Three types of islands were observed, and examination of serial sections stained with hæmotoxylin and eosin showed that these corresponded with inflammatory and biliary cell foci, necrotic and degenerate parenchymal cells and morphologically normal parenchymal cells. The islands of non-staining, but morphologically normal, parenchymal cells were usually observed in sections in which non-staining necrotic areas were also present; these islands may represent an early stage in the evolution of the necrotic lesion. Occasionally we observed the persistence of non-staining islands of morphologically normal parenchymal cells after discontinuing administration of the carcinogen for two or more weeks, and these areas might represent microscopic cancerous or precancerous foci. The persisting non-staining foci may have consisted of cell populations which had directively progressed towards carcinogenesis, possibly by release from homœostatic control by the loss or modification of 'self-marker' recognition characters. Alternatively, the persisting foci might result merely from a process of continuing degeneration and regeneration. Weiler has observed uniform staining in sections of some livers several months after discontinuing feeding the dye to the rats. He attributed the uniform staining to a "reconstitution of organ specific antigen". However, it is difficult to exclude the possibility that in such cases only the necrotic type of non-staining islands had developed during dye administration, and that regeneration of the normal cell population was

accompanied by the recovery of normal staining characteristic.

The results of our investigations in no way invalidate the concept that the malignant cell has lost the 'self-marker' recognition unit(s) necessary for the control of multiplication. Indeed, the histochemical appearances observed by Weiler may well be an expression of deletion or alteration of the highly specific dye-binding protein(s) investigated by Miller and Miller[7]. Although we have reproduced the non-uniform staining which Weiler has observed in sections of livers from rats fed on azo dye, we are unable to confirm his interpretation that the loss of organ specificity is involved in the phenomenon.

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Effect of Relative Humidity on Rat Breeding and Ringtail

For several years we had very great difficulties in the breeding of rats in our laboratory. The troubles occurred from late autumn until early spring. The death-rate of new-born rats was high, and among the survivals ringtail[1] was widespread.

Breeding difficulties have been reported when cages with wire bottoms are used[2]. Symptoms resembling ringtail have been described in essential fatty acid deficiency and 'cold injury' in experimental rats, and in zinc deficiency in the suckling mouse[3].

Dietary changes, as well as use of soft paper as nesting material, failed to effect improvement of the condition. In all experiments we used metal cages with wire bottoms and fronts. As breeding was normal during the summer, the type of cage *per se* could not be the main reason for the difficulties in the winter.

In 1954, Mrs. C. D. Dickinson, of the Royal Free Hospital, London, suggested to one of us (L. R. N.) that control of the relative humidity in the breeding rooms might be rewarding. In Bergen, relative humidity in rooms maintained at temperatures of 21°–22° C. will fall below 40 per cent during winter-time. During periods of low outside temperatures, relative humidities of about 30 per cent are recorded. Since 1954 we have, with considerable difficulty, maintained our breeding rooms at relative humidities above 50 per cent. During the past two winters a humidifier has kept the rooms hygrostatically at relative humidities in the range 55–65 per cent.

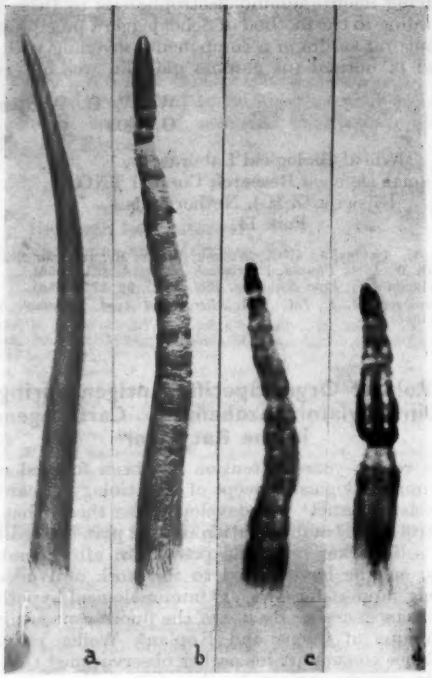

Fig. 1 *a*, Normal tail; *b*, *c* and *d*, different stages of ringtail

These measures have given very good results: breeding during the winter has been as good as that in summer, and symptoms of ringtail have disappeared almost completely.

The results were so striking that we have continued investigations into the problems. This winter, seven pregnant rats were transferred to a room without humidity control. The young were inspected one week after birth. All of them showed abnormalities of their tails, ranging from slight scaliness to very severe annulation. Some of the rats recovered as time passed. At three weeks, thirty-three out of a total of sixty-three showed various degrees of tail disorders, ranging from slight scaliness over annulation and reddening of the tail tip, to complete necrosis of the tail and its final dropping off (Fig. 1). All young survived the suckling period. Incidentally, the winter was mild so that relative humidity recorded in this room was only slightly below 40 per cent compared with about 30 per cent recorded in earlier winters. This may explain the better survival. In the humidified breeding rooms, sisters of the above females bore and reared sixty-two young, of which only three showed signs of tail disorders.

It is suggested that the reason for the tail disorder observed when relative humidity is low may be a great heat-loss from the naked new-born rat due to evaporation. Arterio-venous anastomoses with relative great diameters are found in the tail of the rat[4]. The rat may therefore reduce its surface area and correspondingly its heat-loss by reduction of the blood flow through the tail. If this be continued for some time, necrosis of the tail may result.

The severity of tail symptoms in rats deficient in fatty acids is reported to be dependent on the relative humidity[5]. This, in connexion with the

finding that such rats have an elevated metabolism[4], seems to indicate that heat-loss is counteracted both by reducing the blood flow through the tail and by a greater heat production. This would be in good agreement with our findings.

Work on the problem of ringtail is being continued. It was, however, thought to be of some value to publish this preliminary communication before next winter, in case other laboratories have experienced similar troubles to those related here.

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Underwater Sounds heard from Sperm Whales

WHILE the sperm whale (*Physeter catodon*) is one of the more conspicuous cetaceans, it has not figured among the relatively few that have been demonstrated to make underwater sounds, although they have occasionally been suspected of doing so. We have now obtained reliable evidence that they, too, are soniferous.

On March 28, 1957, off the North Carolina coast, our vessel *Atlantis* encountered five sperm whales which permitted the ship to approach as close as 15 metres. During the hour spent with the whales, the engines were frequently shut off to permit listening by means of the echo-sounding receiver. Unfortunately phonographic equipment was not available.

Three types of sound were distinguished. The first, heard before the whales were sighted, was a muffled, smashing noise, with impulses about half a second apart, increasing in intensity to the end of the series. At first it was supposed to be hammering somewhere in the ship, but it was determined that the sound was not made on board. Later, when the whales were in plain sight most of the time, this sound was less conspicuous. A second sound was a grating sort of groan, very low in pitch, which reminded some of a rusty hinge creaking. This lasted as long as five seconds at a time. By far the most common sounds were series of sharp clicks, which were loud enough to blacken the sounding recorder paper, and which usually occurred at intervals of about half a second, but occasionally as rapidly as about five clicks per second. As many as 73 successive clicks were counted. They usually came in groups of 20 or so. Different individuals chimed in from time to time, and there was no period of more than a few seconds without clicks.

The echo-sounding receiver was used for listening on at least thirty different occasions before and after this encounter, and no similar noises were heard.

These observations on *Atlantis* were made by Worthington. It is to be hoped that they will be repeated by others fortunate enough to meet sperm whales, and that they will be supported by phonographic recordings. Although relatively few ships carry broad-band listening and recording gear, many nowadays have echo-sounding equipment. Ordinarily, this can be used for listening, with the transmitter silenced. It is true that most such devices will convey an imperfect version of the sounds heard, since they are designed for a very narrow frequency band centred on the transmitting frequency, and are then often heterodyned well down the spectrum. This, for example, applies to the sounds reported by Worthington, whose equipment selected and emphasized frequencies between 10–17 kc./s. and delivered them to him near 4 kc./s. Nevertheless, at this early stage in our study of marine sounds, such a phonograph record may still be of value, especially if the characteristics of the listening and recording system are known.

While the absence of adequate records makes the matter speculative, it seems likely that the clicks heard by *Atlantis* may correspond to the familiar clicks employed in echo-location by the smaller odontocetes[1]; the 'groan' reported by Worthington may turn out to be a rapid succession of clicks.

Occasionally, in the accounts of the nineteenth-century open-boat sperm whalers, there are allusions to comparable sounds made by the quarry. Thus Bennett's creaking[2] reminds one of Worthington's groan. One of the last of the New Bedford whalers, the late Mr. Henry Mandly, jun., has told Schevill of hearing, in calm weather, impulsive noises from below while waiting in the boats for sperm whales to reappear; these he said were believed to be the whale "snapping his spouters". In spite of the allusions of Davis[3], which describe this act as occurring in air at the surface, it seems improbable that the blowhole as such is involved. Possibly this 'snapping' and Worthington's loud clicks are the same. It is quite likely that the whalers, undisturbed by engine noises, could at times have heard these abrupt under-water sounds.

Note added in proof. On June 4 and 27, R. H. Backus, in our vessel *Bear*, succeeded in making phonographic recordings of sperm whales some 200 miles south of Cape Cod. These recordings closely resemble Worthington's description.

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Woods Hole, Massachusetts. April 24.

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Precision Determination of Cell Dimensions by the Back-Reflexion Weissenberg Method

ALTHOUGH it provides an elegant and accurate means of determining crystal lattice parameters, the back-reflexion Weissenberg method has not been widely used since it was first proposed in 1937 [1,2]. Originally a special camera was built for taking back-reflexion Weissenberg photographs, and it is presumably the lack of this instrument in most crystallographic laboratories that accounts for the neglect

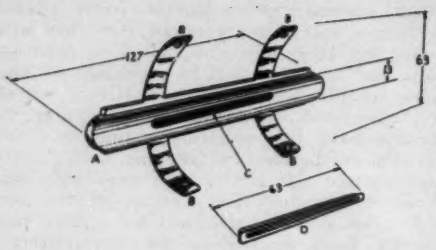

Fig. 1. The Weissenberg back-reflexion adaptor, *A*, fits into the collimator slot of the film holder and is held by the arms *B*. The insert *D* fits into the slit *C*. The approximate dimensions on the figure are given in millimetres

of the method. However, a special camera is not necessary as an ordinary (and widely available) front-reflexion Weissenberg camera can be easily converted into a back-reflexion instrument. The method of conversion described below applies specifically to front-reflexion Weissenberg cameras of the type described by Buerger[2], and may require modification before it can be applied to other designs.

The collimator slot of the film-holder is closed with a removable adaptor machined to have the same internal radius as the film-holder itself (Fig. 1). This adaptor carries a central slit (63 mm. × 3 mm.) for a collimator made of brass tubing having an outside diameter of 1 mm. The film has a slot 63 mm. × 3 mm. cut in it with a special punch and is mounted in the Straumanis fashion. An insert in the collimator slit holds the film firmly against the adaptor and also prevents leakage of light. The conventional layer-line screen is used rotated 90° from the front-reflexion position, the collimator passing through the circumferential slit of the layer-line screen. The beam-stop is mounted on the (removable) lid of the layer-line screen. The camera translation corresponding to a crystal rotation of 240° is reduced to 6 cm. by replacing the bevel-gear on the worm shaft of the Weissenberg mechanism by another bevel-gear with half the number of teeth. The photographs have a distorted scale[2], and central reciprocal lattice rows appear along straight lines slanting at angles of 75° 58′; the maximum Bragg angle that can be recorded on a film holder 57·3 mm. in diameter is 85°. Conversion of the instrument from the front-reflexion to the back-reflexion condition, or vice versa, takes only a few minutes and requires no delicate adjustments; the settings of crystal and camera are not disturbed.

The modified instrument has been used in this laboratory to determine the cell dimensions of a number of orthorhombic and monoclinic crystals. After extrapolation against $\cos^2\theta$ to $\theta = 90°$, the standard deviations of the cell dimensions were about ± 0·0025 per cent in favourable instances. Full details of these results will be published elsewhere.

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Pretoria, South Africa.
March 26.

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Crystal Structure of Calcium Monoaluminate

The crystal structure of calcium monoaluminate ($CaAl_2O_4$) was first examined by Heller[1] in connexion with work on the cementing properties of aluminous cement. Owing to the difficulty of preparing single crystals, a twinned crystal had to be used and the structure was, in consequence, only partially solved. In the present investigation it was possible to cut single-crystal fragments from large crystals selected from a sample of phosphorus furnace-slag[2].

The monoclinic unit cell, space group $P2_1/n$, has cell dimensions $[a] = 8·69$, $[b] = 8·09$, $[c] = 15·21 \pm 0·02$ A., $\beta = 90° 8'$, which are substantially the same as those reported by Heller[1]. The observed density of 2·96 gm. cm.$^{-3}$ agrees well with the calculated density of 2·94 gm. cm.$^{-3}$ and indicates that the cell contains twelve molecules of $CaAl_2O_4$.

An interpretation of the *b*-axis Patterson synthesis, taken in conjunction with packing considerations, led to trial structures for two projections. The co-ordinates were refined by means of electron density and difference Fourier syntheses; the final reliability indices were $R_{h0l} = \Sigma(|F_o| - |F_c|)/\Sigma|F_o| = 0·13$ and $R_{0kl} = 0·11$. Finally, structure factors were calculated for 2,400 *hkl* reflexions, to give a reliability index, $R_{hkl} = 0·13$. The structure is shown in Fig. 1.

Calcium monoaluminate, like kalsilite[3] and nepheline[4], is related structurally to β-tridymite[5]. As a result of substituting all the silicon by aluminium atoms, an unusual three-dimensional arrangement of linked tetrahedra is formed.

The calcium atoms are accommodated in cavities caused by the distortion of the tridymite-like structure. Two calcium atoms (Ca_2 and Ca_3) are each surrounded by six oxygen atoms in an octahedral arrangement, at a mean distance of Ca—O = 2·43 A.

Surrounding the third calcium atom (Ca_1) near the two-fold screw axis are nine oxygen atoms, at distances from it ranging from 2·36 to 3·17 A. Six of these oxygen atoms, each shared by two calcium atoms, form an elongated octahedron, thereby forming a continuous chain composed of —$Ca^{2\cdot43}$ (3) $O^{2\cdot65}$ Ca—. The remaining three oxygen atoms lie, at a greater distance away (Ca—O = 3·03 A.), in the plane at right angles to the chain. A nine-co-ordinated chain occurs in the mineral fluorapatite[6], but in this case the shared oxygen atoms form a trigonal prism around the calcium atom.

There are twenty-four Al—O distances having values between 1·68 and 1·82 A., and the thirty-six

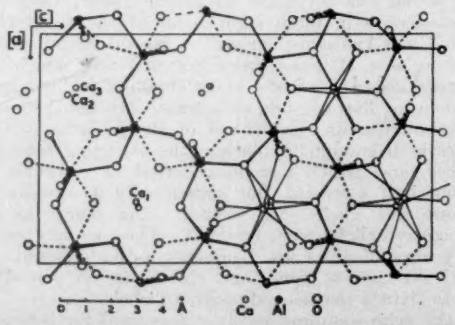

Fig. 1. The *b*-axis projection of $CaAl_2O_4$ showing, on the left, Al—O linkages and, on the right, Al—O and Ca—O linkages. Bonds in lower layer—broken line; bonds in upper layer—full line

O—Al—O angles lie between 101° and 118°. The Si(Al)—O—Si(Al) angles, which in tridymite[5] are all 180°, are in kalsilite[3] straight only in the c-direction; all others approximate to the tetrahedral angle. In calcium monoaluminate, Al—O—Al angles in the pseudo-hexagonal direction have a mean value of 132°, others being approximately 120°.

Full details of this structure will be published elsewhere.

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Albright and Wilson (Mfg.), Ltd.,
Oldbury, Birmingham.
April 29.

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Twinning and the Tabular Growth of Silver Bromide Crystals

SILVER bromide has the sodium chloride-type structure, so that a perfect crystal, growing in a uniform environment, would not be expected to show any tendency to unsymmetrical growth. The fact that dispersions of silver bromide in gelatin, for example in photographic emulsions, can be obtained which do consist of regular polyhedra (Fig. 1) shows that a uniform environment for growth can be obtained. In the same environment during growth, but with different conditions of nucleation, however, dispersions can be obtained in which the crystals are tabular, the tabular faces having triangular or hexagonal shapes (Fig. 2). It can be shown that under identical environmental conditions, the uniform growth in three dimensions of the regular polyhedral crystals proceeds much more slowly than the 'outward' growth of the tabular crystals, that is, the tabular growth is due to enhanced growth parallel to the tabular faces rather than to repression of growth on these faces.

The tabular faces are (111), and, since crystal imperfections are known to promote crystal growth, it can be inferred that the tabular crystals contain some imperfection which promotes growth parallel to the two (111) planes forming the tabular faces.

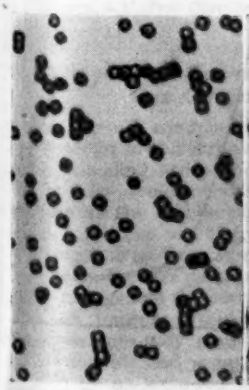

Fig. 1

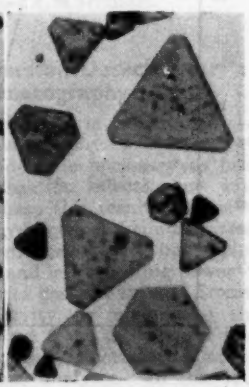

Fig. 2

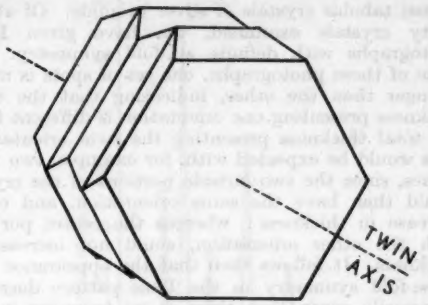

Fig. 3

Twinning is a very common occurrence in crystals, and since in silver bromide a triad axis is the only simple one which could form a twin axis, it is of interest to speculate whether the tabular growth of silver bromide can be explained by twinning.

Successive twinning with a common triad axis will give a crystal of the shape shown in Fig. 3. This possesses two flat parallel (111) faces (tabular faces) perpendicular to the common twin axis, but the 'sides' of the crystal are saw-tooth in cross-section, consisting of alternate 'troughs' and 'ridges', the total number of troughs plus ridges per side being equal to the number of twin planes. Enhanced rate of growth of the sides of the crystal over that on the tabular faces could be explained by making the plausible assumption that the troughs on the sides facilitate nucleation for deposition of successive ionic layers relative to that on the flat tabular faces.

If each twin boundary in the crystal is a single continuous (111) plane, then—if the sides are numbered in rotation 1, 2, 3, 4, 5, 6—sides 1, 3 and 5 form a set of three sides which are identical as regards the number of troughs. Sides 2, 4 and 6 also form a similar set but possess the same number of troughs as the first set only when an even number of twin planes are present in the crystal. For odd numbers of twin planes $(2n-1)$ there will be three sides with $(n-1)$ troughs and n ridges and three sides with n troughs and $(n-1)$ ridges.

If the rate of growth of a side is dependent on the number of troughs on that side, then it follows that the sides in either set of three will all grow at the same rate, but not necessarily at the same rate as the other set of three, that is, the tabular faces will have three-fold symmetry, but not necessarily six-fold symmetry. Tabular crystals with three-fold symmetry of the type shown in Fig. 2 are very common in photographic emulsions.

If the twin planes were formed only in the nucleation stage, then simple ratios between the lengths of adjacent sides might be expected. It is very probable, however, that further twin planes are formed also during the subsequent growth of a crystal, so that the final ratio will not only depend on the number of twin planes present, but also on the times at which each plane was formed during the growth of the crystal.

A Laue photograph taken perpendicular to a (111) plane of a single crystal of the sodium chloride-type structure would only show three-fold symmetry, but if twinning occurs six-fold symmetry would be expected. Laue photographs of this type have been taken in these laboratories, using large (30–50μ

across) tabular crystals of silver bromide. Of about thirty crystals examined, ten have given Laue photographs with definite six-fold symmetry. In some of these photographs, one set of spots is much stronger than the other, indicating that the total thickness presenting one orientation is different from the total thickness presenting the twin orientation. This would be expected with, for example, two twin planes, since the two outside portions of the crystal would then have the same orientation, and could increase in thickness; whereas the centre portion, with the other orientation, could not increase in thickness. It follows then that the appearance of a three-fold symmetry in the Laue pattern does not necessarily mean that there is no twinning in the crystal, but merely that the total thickness of one section of the same orientation is insufficiently great to yield a visible Laue pattern.

The twinning hypothesis in its simplest form is not sufficient to explain all the tabular shapes observed in silver halide dispersions, but it can explain those of most frequent occurrence. Twinning on a plane of bromide ions can occur without steric hindrance, and there is experimental evidence to suggest that only this type of twinning occurs.

Twinning in silver halide crystals has been referred to in a paper by Evans and Mitchell[1]. Although those authors consider twinning in silver bromide as unlikely, they think that the development of twinned crystals could explain the formation of certain triangular crystals which they obtained.

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Foreign Cations in Silver Azide

The optical and decomposition properties of inorganic compounds can very often be changed by the introduction of small amounts of foreign cations or anions. For inorganic azides which decompose rapidly on heating, the usual method of incorporating impurities, which involves recrystallization from the melt, cannot be used. Gray and Waddington[1] have reported on the properties of silver azide (AgN_3) containing traces of the cyanamide ion, and this communication is concerned with the method and effect of introducing metal impurities such as cadmium into crystals of silver azide.

The silver azide crystals were prepared from $^{109}AgNO_3$ provided by the Atomic Energy Research Establishment, Harwell. One mode of decay of the silver isotope involves the emission of a β-particle to form cadmium.

The active silver azide was crystallized from ammoniacal solution and stored under water in the dark. A control sample of normal silver azide was prepared and stored under similar conditions. With the sample of silver-110 provided (3·5 mcurie/gm. of silver nitrate) the percentage of silver converted to cadmium after 270 days was approximately $6' \times 10^{-5}$ per cent. After this period of time the crystals of active silver azide were a reddish-brown colour

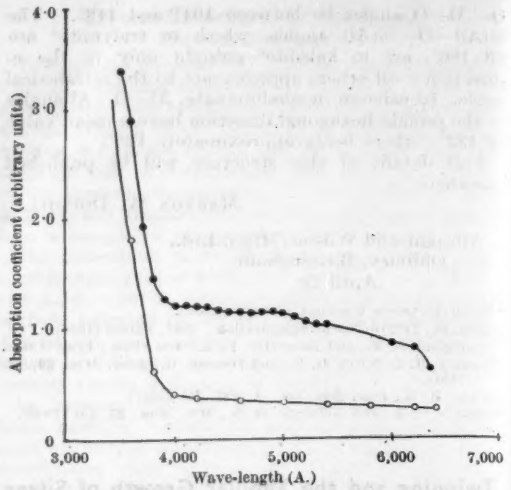

Fig. 1. Absorption spectra of silver azide: ● 'active'; ○, normal

compared with the normal colourless crystals in the control experiment. The absorption spectra are shown in Fig. 1.

X-ray patterns, from a single crystal and powder of the active silver azide, showed no detectable change from similar patterns of normal silver azide. This was probably due to the fact that the percentage change of silver to cadmium was too small. A further limitation was that silver azide decomposes when irradiated with X-rays, which reduces the length of exposure that may be given. Three hundred days after being prepared, the emission from the active silver azide was still sufficient to give a slight overall fogging of the film in the X-ray camera.

Associated with the change in absorption spectra shown in Fig. 1, there is a change in the variation of refractive index with wave-length (Fig. 2) compared with normal silver azide[2]. This new absorption band also effectively suppresses the photoconductive properties normally exhibited by silver azide. On dissolving a crystal of active silver azide in ammonia, it was found that the reddish colour was present

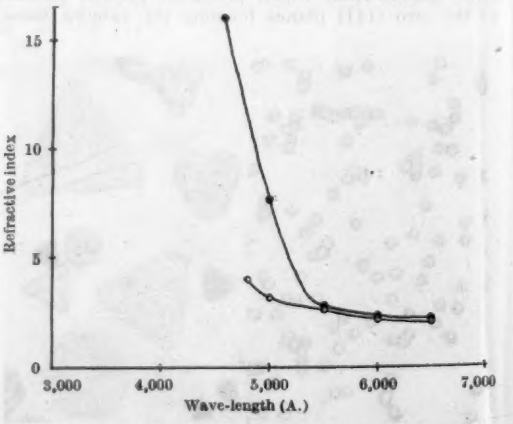

Fig. 2. Variation of refractive index with wave-length for silver azide: ●, 'active'; ○ normal

throughout the bulk of the crystal. A very fine metallic network remained after all the azide had been dissolved. Crystals of active silver azide are also more sensitive to light than normal silver azide.

Cadmium azide normally exists in the divalent form $Cd(N_3)_2$. Thus it is clear that if, as a result of radioactive decay, molecules of cadmium azide are formed then there will be an excess of silver ions. Silver azide has a high ionic mobility at room temperature. It will be possible for the silver ions to acquire the necessary negative charge to give rise to a silver precipitate in preferred regions of the lattice. This is probably responsible for the new absorption spectra[3].

The detonation velocity of long needles of active silver azide was determined by S. K. Deb using metal probes in conjunction with a spiral base cathode-ray oscilloscope. He found the average detonation velocity (m./sec.) of crystals of length about 1 cm. and diameter 0·3–0·4 mm. when ignited by a hot platinum wire is: pure silver azide, 1,500; 'active' silver azide, 2,200.

This 50 per cent increase in detonation velocity may be due either to the presence of $Cd(N_3)_2$ molecules or to the finely dispersed silver. The latter mechanism is considered the more probable as it has been shown that normal silver azide may be sensitized to flash initiation by incorporating gold powder in compressed pellets of silver azide (Evans, B. L., and Yoffe, A. D., unpublished work). The metal acts as an electron trap and increases the rate of decomposition.

The introduction of cadmium and consequent formation of free silver have thus been responsible for a considerable modification in the properties of silver azide crystals. It is interesting that the presence of such small concentrations of impurity (< 1 in 10^6) can bring about this marked change in detonation velocity.

We are grateful for the assistance given by Dr. J. Sawkill, and for the encouragement afforded us by Dr. F. P. Bowden.

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B. L. Evans
S. K. Deb

Research Laboratory on the
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Department of Physics,
Cambridge. May 1.

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A Hydrogen-Conversion Detector for Gas Chromatography

The thermal conductivity cell is in common use as a detector in gas chromatography. When separating high-boiling compounds it is necessary to heat the cell to avoid condensation effects, but with nitrogen as the mobile phase this results in loss of sensitivity. The use of hydrogen or helium instead of nitrogen is said to improve sensitivity but apparently gives broader peaks and less resolving power[1,2]. Using nitrogen as the carrier gas, Martin and Smart[3] obtained improved sensitivity by converting the compounds as they emerged from the column into carbon dioxide and water, and detecting the carbon dioxide by an infra-red gas analyser. In this laboratory this technique has been tried using a thermal conductivity cell to detect the carbon dioxide after removal of water vapour. In our experience this method gives increased sensitivity but is accompanied by some band spreading and consequent loss of resolution.

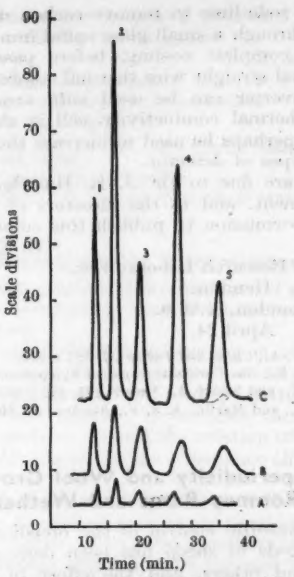

Fig. 1. Chromatograms of equal weights of a mixture of (1) cinnamaldehyde, (2) butyl benzoate, (3) coumarin, (4) phenyl propyl butyrate, (5) β-naphthyl methyl ketone. Nitrogen flow, 13 ml./min. Column temperature 195° C. Curve *A*, normal system, catharometer temperature 122° C., total sample 1 mgm. Curve *B*, conversion to carbon dioxide, total sample 1 mgm. Curve *C*, conversion to hydrogen, total sample 1 mgm.

Much improved sensitivity with excellent resolution is obtained by converting the water vapour to hydrogen and removing the carbon dioxide. The increase in sensitivity is due to the much greater difference between the thermal conductivities of hydrogen and nitrogen than between those of carbon dioxide and nitrogen. The increase in sensitivity can be seen by reference to Fig. 1. The three curves represent the separation of the same mixture of five high-boiling compounds containing carbon, hydrogen and oxygen only, the same sample weight being taken in each case. Curve *A* shows the trace (Sunvic recorder 0–2·5 mV. range) using an electrically heated thermal conductivity cell running at 122° C. This was found to be the lowest temperature at which the cell could be run to avoid condensation effects, the compounds boiling in the range 250–300° C. Curve *B* shows the trace after each compound had been converted to carbon dioxide, the thermal conductivity cell now operating at room temperature. Curve *C* shows the trace after conversion to hydrogen and removal of carbon dioxide. The peaks in this case occur in the opposite direction, but are shown reversed for clarity. A tube 4 mm. in diameter and 5 ft. long packed with 20 per cent w/w silicone grease and 'Celite' 545 was used for the separation in the manner described by James and Martin[4].

The hydrogen converter is simply made from a 30-cm. length of silica tubing 4 mm. in diameter, packed in two 10-cm. sections, one filled with copper oxide and the other with iron powder. The whole tube is heated electrically to red heat. From this combustion tube the gases pass first through a short

column of soda-lime to remove carbon dioxide, and secondly through a small glass spiral immersed in oil to ensure complete cooling, before passing into a conventional straight wire thermal conductivity cell.

The converter can be used with any apparatus where a thermal conductivity cell is the detector, and could perhaps be used to increase the sensitivity of other types of detector.

Thanks are due to Dr. J. R. Hawthorne for his encouragement, and to the directors of Schweppes, Ltd., for permission to publish this communication.

G. E. Green

Schweppes Research Laboratories,
Hendon,
London, N.W.9.
April 24.

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Photoperiodicity and Wool Growth in Romney Rams and Wethers

Photoperiodic control of the breeding season in several breeds of sheep has been demonstrated by Yeates[1] and others, and the effect of light as a stimulant to growth and shedding of hair in some mammals has also been investigated. Some wool-production responses of New Zealand Corriedale ewes to photoperiodic stimuli have been described by Hart[2,3]: ewes which had endured constant artificial light/dark rhythms produced for several months a greater weight of wool than they had done before the treatment and greater than control ewes subjected to the normal solar-light rhythm. It is thought that, succeeding the initial reception by the eyes of the light stimulus, impulses travel neurally to the hypothalamus and from there the activity of the adenohypophysis is controlled possibly by a neuro-humoral link; the activity of the adenohypophysis may then influence the rate of wool growth either by thyrotrophic or growth hormones. Hart[3] supplied evidence supporting the view that "the photoperiodic response in wool growth may be due to an increased thyrotrophic activity of the pituitary"; in one experiment he subjected a group of ewes to a fixed rhythm of two hours light to four hours darkness and after a latent period there was a marked response in wool growth by these animals. Hart cited this result in support of the 'contrast sensitivity' theory of reaction by the complex responsible for the expression of photoperiodic stimuli.

An experiment was commenced at the Rowett Research Institute, Aberdeenshire, by this department on June 1, 1955 (pre-experimental period March–May), and it was designed with the following objectives: (1) Generally, to investigate wool growth responses by English Romneys to photoperiodic stimuli, using control sheep subjected to the normal seasonal solar-light–darkness rhythms experienced in Scotland. (2) To find out the wool growth responses to light stimuli by wethers and rams. So far as we know, these have not been previously investigated and such material was, of course, not complicated by events in the œstrous cycle. (3) To obtain evidence of possible responses in the form of the degree of fibre shedding.

A group of twelve Romney Marsh sheep, consisting of four rigs, one ram and seven wethers, were tested and ranked for level of clean wool production from tattooed squares during a pre-experimental period; they were then allocated to either the control or the experimental group, each numbering six sheep. From June 1, 1955, both groups were indoors in individual pens and fed exactly the same ration of concentrates and chopped hay with water *ad libitum*. The control group experienced natural solar-light–darkness rhythms throughout and the experimental group was in an adjacent blacked-out room, enduring a continuous fixed 2 : 1 rhythm of eight hours darkness to four hours electric light supplied by two 100-watt bulbs: this rhythm was maintained without alteration during the period June 1955–October 1956. Mean weekly temperatures were approximately the same in experimental and control rooms, the temperature not being controlled but varying with season. Wool from each of four tattooed areas on each sheep was cut at skin-level every two months, receiving a standard washing and the weight being determined under standard conditions. Results have been statistically analysed. The areas of the tattooed squares were measured at each sampling time and skin samples taken periodically for S/P, and other information which will be communicated in a more detailed account of the experiment to be published later. The treatment ended on October 17, 1956, when all the sheep were put outside; shortly after this the feeding of concentrates to both groups ceased. No attempt was made to test by injection any effects on wool growth of specific hormones.

Fig. 1 shows the total clean conditioned weight of wool grown during successive two-monthly periods

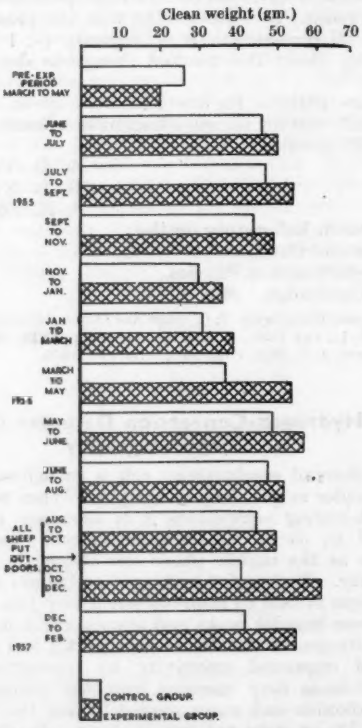

Fig. 1. Weight of clean wool conditioned to 67° C., 68 per cent relative humidity from tattooed squares

from the tattooed skin areas (this expresses the changing capacity for wool production better than it would be expressed as weight per unit area of skin). Results obtained so far may be summarized as follows:

(1) Results agreed with those of Hart in supporting the 'contrast sensitivity' theory of response in wool growth to photoperiodic stimuli.

(2) Although at the end of the pre-experimental period the sheep in the experimental group had produced less clean wool from their marked areas than that grown by the marked regions of the controls, during the period August–September 1955 they had begun to produce a significantly greater weight of wool than that grown by the controls. There continued to be a margin between the two groups until during March–May 1956 the experimental group reached a peak, producing about 48 per cent more wool than the controls. The margin between the two groups was then gradually reduced through the summer until October of the same year (1956). The remarkable rise in production of clean wool (approximately 50 per cent more than the controls) by the experimental animals during the two months (October–December) immediately following the conclusion of the experimental period indoors is shown in Fig. 1. This occurred in spite of the fact that (*a*) wool production of the control animals had declined, (*b*) the value of the pasture was beginning to deteriorate at this season, and (*c*) both control and experimental animals were now together outdoors under the same conditions. During the following period, December–February, the margin, although slightly reduced, was still high. Sampling will continue and it is hoped to elucidate further the responses in these and other sheep. It is clear, however, that this high production during four months of what is normally a low wool-producing season has significant practical implications.

(3) The difference in wool production between the two groups changed significantly with time during the experiment (groups × times interaction significant at the 0·1 per cent level).

(4) Seasonal variations in wool production have been described before: again in this experiment a seasonal variation with a peak each summer has been demonstrated by both groups while they were housed, and the variation is independent of either level of feed or photoperiodicity.

(5) The curve for mean monthly ambient air temperatures was closely followed by those for clean-wool production of both groups throughout the experiment. It is not certain that external temperature had an immediate and direct effect on seasonal variation in wool production, but it is probable that variation in temperature was a contributory factor.

(6) From a wool-production point of view, rams and rigs behaved no differently from the wethers.

I am grateful to Dr. D. P. Cuthbertson, director, J. C. Gill, J. Wood and others on the staff of the Rowett Research Institute for facilities and maintenance of sheep during the experiment; also to R. Bell for statistical analyses and to Mrs. S. Webster, research assistant in this Department, for her skill and care in recording data and other work connected with the investigation.

A. B. Wildman

Biology Department,
Wool Industries Research Association,
Leeds. April 18.

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Anisotropy of Sclerotinites

Seyler[1] has measured the reflectance of sclerotinites but has not commented upon the existence of anisotropy in them.

I have found distinct anisotropy in some sclerotinites obtained from coals of widely different geological periods and of widely scattered areas throughout the world. Reflectance measurements have been made in oil and the relation of maximum reflectance (R_1) to minimum reflectance (R_2) has been plotted in Fig. 1. For comparison, the measurements of R_1 and R_2 in respect of vitrinites of different ranks obtained by Broadbent and Shaw[2] have been plotted in the same figure. It will be seen that this relation with sclerotinites and vitrinites appears to follow a straight line up to the R_1 value of about 3 per cent. At this stage the results with vitrinite deviate from the linear relation.

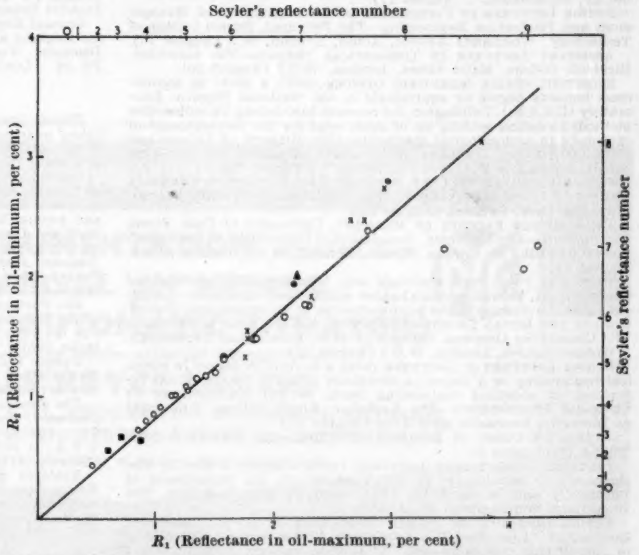
Seyler's reflectance number
0 1 2 3 4 5 6 7 8 9
R_2 (Reflectance in oil-minimum, per cent)
1 2 3 4
R_1 (Reflectance in oil-maximum, per cent)
1 2 3 4
Seyler's reflectance number
1 2 3 4 5 6 7 8

Fig. 1. Relation of maximum (R_1) and minimum reflectance (R_2) in oil for sclerotinite and vitrinite. Sclerotinite: ●, Carboniferous, Barnesley seam, England; ▲, Carboniferous, Harraton Small, England; ×, Permo-carboniferous, Wankie Coal, Southern Rhodesia, Africa; ■, Eocene, lignite from Palana, India. Vitrinite: ○, British carboniferous coals

It will be of interest to ascertain if the values of R_1 and R_2 for other micro-constituents of coal follow similar relations.

D. Chandra

British Coal Utilisation Research Association,
Randalls Road, Leatherhead, Surrey.
April 1.

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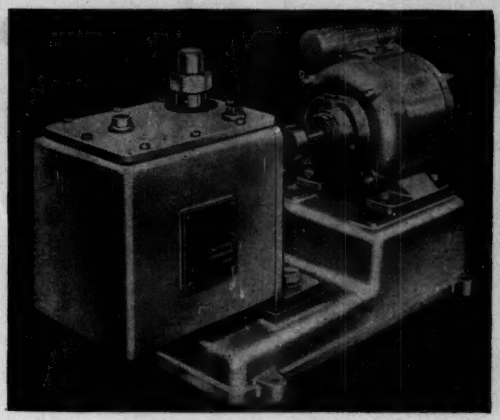

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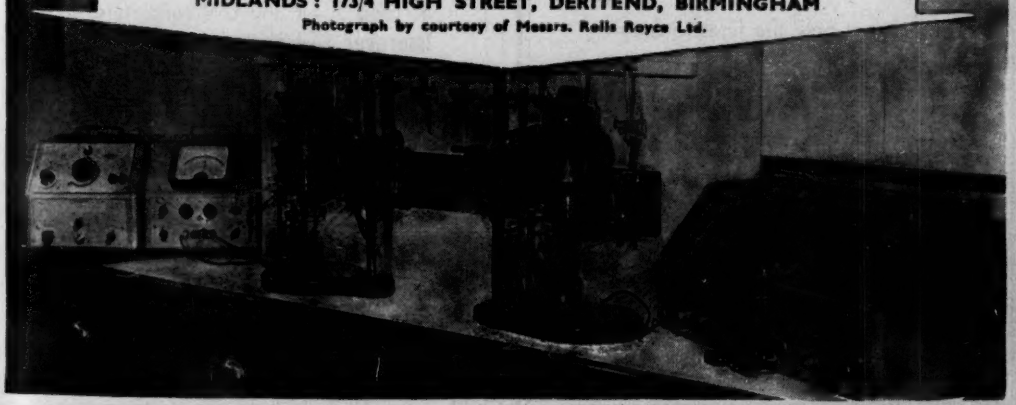

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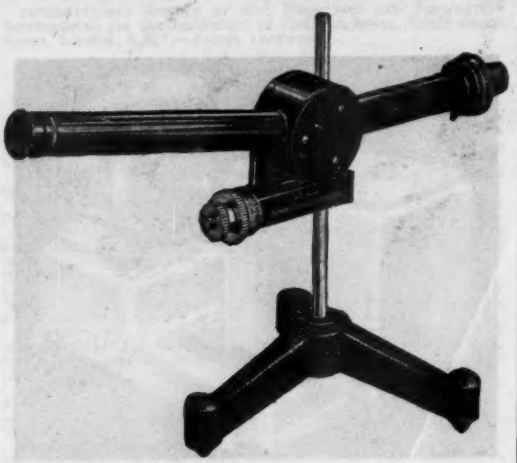

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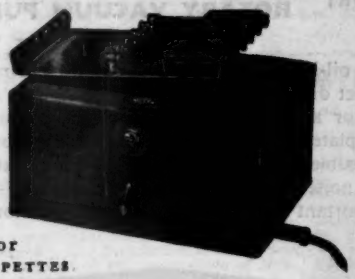

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